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Nine models developed principally for use at the central level of the Bureau of Indian Affairs in evaluating the costs and cost-effectiveness of alternative policies and programs are described in this document. The 9 models are: (1) Population Projection Model, (2) Enrollment Projection Model, (3) Facilities Planning Model, (4) Economic Projection Model, (5) Facilities Location Model, (6) Personnel Projection Model, (7) Equipment Projection Model, (8) Finance Management Information System Model, and (9) School Investment Model. The function of the models is to assemble data in formats useful to planners. They are designed to be programmed on computers, and their descriptions are an aid for computer programmers. For each model descriptions include a discussion of model objectives, inputs, process, and output. Flow charts for the various models are also included. Related documents are RC 003 749, RC 003 751, and RC 003 752. [Not available in hard copy due to marginal legibility of original document.] (SW)

# System Analysis, Program Development, And Cost-Effectiveness Modeling Of Indian Education

For the Bureau of Indian Affairs

VOLUME III

## PLANNING AND COST-EFFECTIVENESS MODELING FOR BIA SCHOOLS



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VOLUME III

Planning and Cost-Effectiveness Modeling for BIA Schools

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# Chapter I
# Introduction

This volume includes descriptions of nine models developed for use principally at the central level of the Bureau of Indian Affairs in evaluating the costs and cost-effectiveness of alternative policies and programs, both present and projected. Their function is principally to assemble data in formats useful to planners, although they perform some calculations and projections as well. They do not eliminate the need for the expertise of the decision-maker, but rather free him from the laborious and repetitive information-gathering tasks.

These models are designed to be programmed on computers, and their descriptions are therefore written for the professionals who will program them. It is recommended that those persons who may be making decisions on the basis of information provided by the models read the textual descriptions at the beginning of each chapter and Chapter X on Examples of General Model Use; that programmers read the volume in its entirety; and that other readers examine only the examples of the models' uses, in order to understand the models' purpose and applications. Chapter XI will also be of interest to the general reader because it discusses the overall selection of the most cost-effective programs generated during the course of the project.

## Modeling Objectives

The first consideration in the development of qualitative or quantitative models is the determination of objectives. The objectives of a model determine what variables and processes are relevant, what kinds of data are reasonable to collect, and how specific the outputs of the model should be. A model for Bureau-wide long-range planning will differ in all the regards from a model which is designed to sensitize teachers to their own classroom behaviors.

In describing the objectives of the different models which have been developed for the Education Division of the Bureau, the implications in these terms of the objectives spelled out will be discussed.

The models are divided into two broad categories. The School Process Model, the Teacher Evaluation Model. the Curriculum Evaluation Model, and the Instructional Process Model are intended primarily for use at the school level and are expected to produce outputs which will be immediately useful to local students, administrators, and teachers. They are presented and explained in Volume IV. The other nine models are intended to be used at the central or area level for long-range planning and for testing of alternative large-scale strategies. These are discussed below.

## Chapter II

## Population and Enrollment Projection Models

### DESCRIPTION OF OBJECTIVES

#### Population Projection Model

Given an initial age distribution in a population and information concerning rates of birth, death, migration, fertility, and infant mortality, the model predicts the age distribution and various demographic statistics for the population at the end of each of an arbitrary number of five-year periods.

#### Enrollment Projection Model

Given information about the age distribution in a population, school enrollment, and enrollment trends, the model predicts the enrollment in each of the school grades at the end of each of an arbitrary number of five-year periods.

### OUTPUTS

One block of output emerges for each five-year period requested. If the initial year were specified at 1969, the first block might have the following appearance:

```
YEAR 1974

TOTAL POPULATION = 14059
CRUDE BIRTH RATE = 28.7
CRUDE DEATH RATE = 5.2                NET INCREASE = 23.5
CRUDE MIGRATION RATE = 9.7
TOTAL BIRTHS = 252  1956
TOTAL DEATHS = 353
AVERAGE AGE = 29.9
AVERAGE AGE AT DEATH = 29.4
RATE OF POPULATION GROWTH = .012
```

| AGE GROUP | NUMBER | PERCENT |
|---|---|---|
| 0-4 | 1563 | 13.3 |
| 5-9 | 1777 | 12.7 |
| 10-14 | 1773 | 12.7 |
| 15-19 | 1877 | 13.4 |
| 20-24 | 1538 | 11.0 |
| 25-29 | 1143 | 8.2 |
| 30-34 | 854 | 6.1 |
| 35-39 | 665 | 4.8 |
| 40-44 | 573 | 4.1 |
| 45-49 | 498 | 3.6 |
| 50-54 | 422 | 3.1 |
| 55-59 | 358 | 2.6 |
| 60-64 | 289 | 2.1 |
| 65+ | 524 | 3.7 |
| TOTALS | 14059 | 100.0 |

The next block would supply the population levels for 1979 and the average rates for the period 1975-1979, and so forth until the end of the requested number of blocks.

INPUTS:

The model requres as input:

--the initial age distribution in the population, $p_{j0}$, by five-year age groups; this is the base line from which the projections proceed.

--dummy age-specific migration rates, $p_{mj}$, assumed to hold constant throughout the projection and assumed to be proportional during any one five-year period to the actual migration rates.

--initial dummy age-specific birth rates $\overset{(1)}{bjo}$, to be altered at each iteration in accordance with assumed changes in fertility; as thus altered, these dummy rates are likewise assumed to be proportional during any one five-year period to the actual birth rates.

--initial crude birth and migration rates $R_{b0}$ and $R_{m0}$, in units of occurrences per 1000 population per year.

--fertility decline coefficient $\delta$, which represents the proportional decline in fertility of the 10-14 and 15-19 age groups at the beginning of the projection run; this decline spreads through the older groups as the projection proceeds.

--estimated age-specific death rates $r_{dj}$; these are actual assumed rates, not dummies, and they are assumed to hold constant through the projection. They are inferred from the life expectation at birth, the infant mortality rate, the crude death rate, and the fertility coefficient, via standard life tables.

--infant survival coefficient , which is the proportion of live births during a five-year period who survive to the end of the period (i.e., to the age of 2 1/2 years, on the average).

--the number T of iterations desired.

--the initial year $Y_o$.

NOTE:

The equations in this model assume that all input variables are supplied either in units of persons (i.e., births, deaths, migrations, etc.), or in units of persons per five-year period (e.g., births per five years). Some of the output statistics are traditionally expressed in other units, such as crude birth rates in births per 1000 population per year, and the model's output follows these conventions. These are merely output manipulations, however, and no deviant units enter into the internal computations of the projection model.

PROCESS:

The model:

--sums the initial age distribution $p_{jo}$ over j to obtain the total initial population.

--computes the proportionality constants $c_b$ and $c_m$ by which the dummy birth and migration rates must be multiplied to be consistent with the initial crude birth and migration rates $R_{bo}$ and $R_{mo}$.

--adjusts the dummy birth rates $\rho^{(1)}_{bjo}$ to interval average values equal to half the sum of the two instantaneous values $\rho^{(2)}_{bjo}$ supplied at the ends of each interval. If the dummy birth rates were initially supplied as interval averages, this process should be eliminated from the model operation.

--applies the assumed fertility decline coefficient $\delta$ to the dummy birth rates $\rho^{(2)}_{b,3,0}$ and $\rho^{(2)}_{b,4,0}$ for the 10-14 and 15-19 age groups, obtaining the actual dummy birth rates $\rho_{bj0}$ that will be used in the first iteration.

Then, for each five-year period desired (that is, T times), the model:

--multiplies the dummy migration $\rho_{mj0}$ and the current values of the dummy birth rates $\rho_{bjt}$ by the corresponding proportionality constants $cx_b$ $c_m$ and $c_b$, obtaining the model's estimates of the true current age-specific migration and birth rates $r_{mj}$ and $r_{bjt}$.

--multiplies the age-specific birth and migration rates $r_{bjt}$ and $r_{mj}$ by the populations $p_{jt}$ of the corresponding age groups, obtaining the model's estimates of $b_{jt}$ and $m_{jt}$, the numbers of births to and of migrations among members of the age groups.

--sums $b_{jt}$ and $m_{jt}$, the births and migrations in the age groups, obtaining $B_t$ and $M_t$, the estimated total numbers of births and migrations in the population.

--computes $d_{1t}$, the number of deaths in the 0-4 age group from $B_t$, the total number of births, and from $\sigma$, the infant survival coefficient.

--computes $d_{jt}$, the numbers of deaths in the older groups, from $r_{dj}$, the assumed age-specific death rates, and from $p_{jt}$, the age-group populations.

--sums the values of $d_{jt}$ over all the age groups, obtaining $D_t$, the estimated total number of deaths in the population.

--applies the assumed fertility decline coefficient $\delta$ to the dummy birth rate $\rho_{b,t+4,t}$ corresponding to the group just older than the last one adjusted (which will be one five-year step older on the next iteration).

--computes the estimated population $p_{1,t+1}$ for the 0-4 age group on the next iteration, using $B_t$, the number of births in the present interval, $M_t$, the number of migrations from this youngest group during the present interval, and , the infant survival coefficient.

--computes the populations $p_{j,t+1}$ of the other age groups for the next iteration, setting each equal to the population $p_{j-1,t}$ of the next younger group at the beginning of the current iteration, less $d_{j-1,t}$ and $m_{j-1,t}$, the deaths and migrations depleting the younger group during the present iteration. The oldest group, age 65+, receives also the surviving non-migrants of the present oldest group.

--sums the age-group populations $p_{j,t+1}$ at the beginning of the next iteration, obtaining $P_{t+1}$, the total population at that point.

--computes and outputs various descriptive statistics concerning the rates of change during the present interval and the state of the population at the beginning of the next.

## POPULATION PROJECTION MODEL

### Variable List and Equations

| | | |
|---|---|---|
| $\overline{A}_{dt}$ | Average age of population members who die during interval t | $\overline{A}_{dt} = \frac{1}{D_t} \sum_{j=1}^{14} (5j - \frac{5}{2}) d_{jt}$ |
| $\overline{A}_t$ | Average age of population members during interval t | $\overline{A}_t = \frac{1}{\overline{P}_t} \sum_{j=1}^{14} (5j - \frac{5}{2}) \rho_{jt}$ |
| $b_{jt}$ | Number of births to members of age group j during interval t | $b_{jt} = r_{bjt} \rho_{jt}$ |
| $B_t$ | Total births during interval t | $B_t = \sum_{j=1}^{14} b_{jt}$ |
| $c_b$ | Proportionality constant for computing birth rates from dummy birth rates | $c_b = \frac{R_{bo} \rho_{jo}}{\sum_{j=1}^{14} \rho_{bjo} \rho_{jo}}$ |
| $c_m$ | Proportionality constant for computing migration rates from dummy migration rates | $c_m = \frac{R_{mo} \rho_{jo}}{\sum_{j=1}^{14} \rho_{mj} \rho_{jo}}$ |
| $CBR_t$ | Crude birth rate during interval t | $CBR_t = 200B_t/\overline{P}_t$ |
| $CDR_t$ | Crude death rate during interval t | $CDR_t = 200D_t/\overline{P}_t$ |
| $CMR_t$ | Crude migration rate during interval t | $CMR_t = 200M_t/\overline{P}_t$ |
| $d_{jt}$ | Number of deaths among members of age group j during interval t | $\begin{cases} d_{1t} = B_t(1-0) \\ d_{jt} = r_{dj}\ {}_{jt}, \; j=2,\ldots,14 \end{cases}$ |
| $D_t$ | Total deaths during interval t | $D_t = {}^{14}_{j=1}\, d_{jt}$ |

| | | |
|---|---|---|
| $j$ | Age group index | $j = 1, \ldots, 14$ |
| $m_{jt}$ | Number of migrations among members of age group j during interval t | $m_{jt} = r_{mj} \rho_{jt}$ |
| $M_t$ | Total migrations during interval t | $M_t = \sum_{j=1}^{14} m_{jt}$ |
| $P_{jt}$ | Population of age group j at beginning of interval t | $\rho_{jo}$ = given<br>$\left.\begin{array}{l} \rho_{1t} = B_{t-1} - \frac{1}{2} M_{t-1} \\ \rho_{jt} = \rho_{j-1,t-1} - d_{j-1,t-1} \\ \quad - m_{j-1,t-1} \quad j=2, \ldots, 13 \\ \rho_{14,t} = \rho_{14,t-1} + \rho_{13,t-1} \\ \quad - d_{14mt-1} - d_{13,t-1} \\ \quad - m_{14,t-1} - m_{13,t-1} \end{array}\right\rbrace \; t = 1, \ldots, T$ |
| $P_t$ | Total population at beginning of interval t | $P_t = \sum_{j=1}^{14} \rho_{jt}$ |
| $\overline{P}_t$ | Average population during interval t | $\overline{P}_t = \frac{1}{2}(P_t + P_{t+1})$ |
| $r_{bjt}$ | Rate of births to members of age group j during interval t | $r_{bjt} = C_b \rho_{bjt}$ |
| $r_{dj}$ | Rate of deaths of members of age group j | $r_{dj}$ = given |
| $r_{mj}$ | Rate of migration of members of age group j | $r_{mj} = C_m \rho_{mj}$ |
| $R_{bo}$ | Initial crude migration rate (in births per capita per five years) | $R_{bo}$ = given |
| $R_{mo}$ | Initial crude migration rate (in births per capita per five years) | $R_{mo}$ = given |
| $T$ | Number of five-year projections desired | $T$ = given |

| | | |
|---|---|---|
| $W_t$ | Population growth rate during interval t | $W_t = \frac{1}{5}\,\mathrm{lag}\,(P_{t+1}/P_t)$ |
| $Y_t$ | Calendar year at beginning of interval t | $\begin{cases} Y_o = \text{given} \\ Y_{t+1} = Y_t + 5 \end{cases}$ $t = 0, \ldots, T-1$ |
| $\delta$ | Fertility decline coefficient | $\delta$ = given |
| $\rho_{bjt}$ | Dummy birth rate in age group j during interval **t**, adjusted for fertility trend | $\begin{cases} \rho_{bjo} = (1-\delta)\rho_{bjo}^{(2)} & j=3,4 \\ \rho_{bjo} = \rho^{(2)}_{bjo} & j=1,2,5,6,\ldots,14 \\ \rho_{b,t+5,t+1} = (1-\delta)\,\rho_{b,t+5,t} & t=1,\ldots, \\ \rho_{bj,t+1} = \rho_{bjt} & \text{otherwise} \end{cases}$ |
| $\rho^{(1)}_{bjo}$ | Unadjusted initial dummy birth rate | $^{(1)}_{bjo}$ = given |
| $\rho^{(2)}_{bjo}$ | Dummy initial instantaneous birth rate in age group j, adjusted for fertility trend | $\rho^{(2)}_{bjo} = \frac{1}{2}(\rho^{(1)}_{bjo} + \rho^{(1)}_{b,j+1,0})$ |
| $\rho_{mj}$ | Dummy migration rate in age group j | $\rho_{mj}$ = given |
| $\sigma$ | Infant survival coefficient (dimensionless proportion) | $\sigma$ = given |

# POPULATION PROJECTION MODEL

English Language Flowchart

START

(C) →

INPUT:
1. Initial population distribution $P_{io}$
2. Initial dummy age-specific birth and migration rates $\rho_{bjo}^{(1)}$, $P_{mj}$
3. Initial crude birth and migration rates $R_{bo}$, $R_{mo}$
4. Fertility decline coefficient
5. Estimated age-specific death rates $r_{dj}$ (from life table)
6. Infant survival coefficient
7. Number of iterations desired
8. Initial year $Y_o$

COMPUTE:
1. Total initial population $P_o$
2. Proportionality constants $c_b$ and $c_m$, linking dummy birth and migration rates to estimated real age-specific rates

ADJUST:
Dummy birth rates $\rho_{bjo}^{(1)}$ to interval average $\rho_{bjo}^{(2)}$

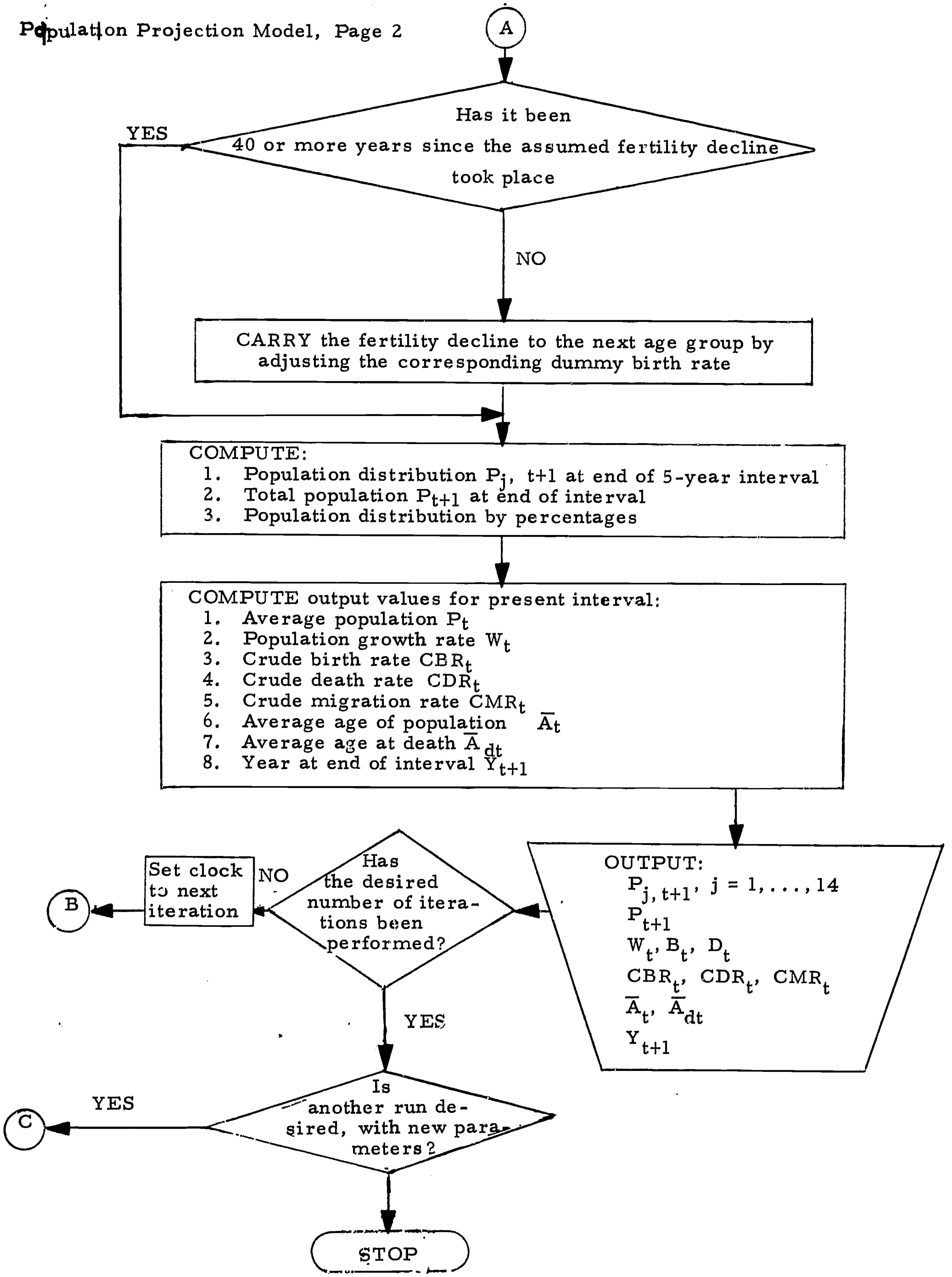
ADJUST:
Dummy birth rates $\rho_{bjo}^{(2)}$ to take account of assumed fertility decline, obtaining final dummy rates $\rho_{bjo}$

Set clock to first iteration

(B) →

COMPUTE:
1. Estimated real age-specific birth and migration rates $r_{bjt}$, $r_{mj}$
2. Estimated numbers of births and migrations during the five-year interval in each age group, $b_jt$, $m_jt$
3. Estimated total births and migrations during the interval $B_t$, $M_t$
4. Estimated deaths in each age group during the interval $d_{jt}$
5. Estimated total deaths during interval $D_t$

(A)


A
Has it been 40 or more years since the assumed fertility decline took place
YES
NO
CARRY the fertility decline to the next age group by adjusting the corresponding dummy birth rate
COMPUTE:
1. Population distribution $P_{j,\ t+1}$ at end of 5-year interval
2. Total population $P_{t+1}$ at end of interval
3. Population distribution by percentages
COMPUTE output values for present interval:
1. Average population $P_t$
2. Population growth rate $W_t$
3. Crude birth rate $CBR_t$
4. Crude death rate $CDR_t$
5. Crude migration rate $CMR_t$
6. Average age of population $\overline{A}_t$
7. Average age at death $\overline{A}_{dt}$
8. Year at end of interval $Y_{t+1}$
OUTPUT:
$P_{j,t+1}$, $j = 1, \ldots, 14$
$P_{t+1}$
$W_t$, $B_t$, $D_t$
$CBR_t$, $CDR_t$, $CMR_t$
$\overline{A}_t$, $\overline{A}_{dt}$
$Y_{t+1}$
Has the desired number of iterations been performed?
NO
Set clock to next iteration
B
YES
Is another run desired, with new parameters?
YES
C
STOP

# POPULATION PROJECTION MODEL

## Detailed Mathematical Flowchart

START

INPUT:

1. $P_{jo}$
2. $\rho^{(1)}_{bjo},\ \rho_{mj}$
3. $R_{bo},\ R_{mo}$
4. $\delta$
5. $r_{dj}$
6. $\sigma$
7. $\tau$
8. $Y_o$

(C)

1. $P_o = \sum_{j=1}^{14} P_{jo}$

2a. $C_b = \dfrac{R_{bo} P_{jo}}{\sum_{j=1}^{14} \rho_{bjo} P_{jo}}$

2b. $C_m = \dfrac{R_{mo} P_{jo}}{\sum_{j=1}^{14} \rho_{mj} P_{jo}}$

$$\rho^{(2)}_{bjo} = \frac{1}{2}\left(\rho^{(1)}_{bjo} + \rho^{(1)}_{b,j+1,0}\right) \qquad j = 1, \ldots, 14$$

$$\rho_{bjo} = (1-\delta)\,\rho^{(2)}_{bjo} \qquad j = 3, 4$$

$t = 0$

(B)

1a.) $r_{bjt} = C_b \rho_{bjt}$

2a.) $b_{jt} = r_{bjt} P_{jt}$

3a.) $B_t = \sum_{j=1}^{14} b_{jt}$

4a.) $d_{1t} = B_t(1-\sigma)$

5.) $D_t = \sum_{j=1}^{14} d_{jt}$

1b.) $r_{mj} = C_m \rho_{mj}$

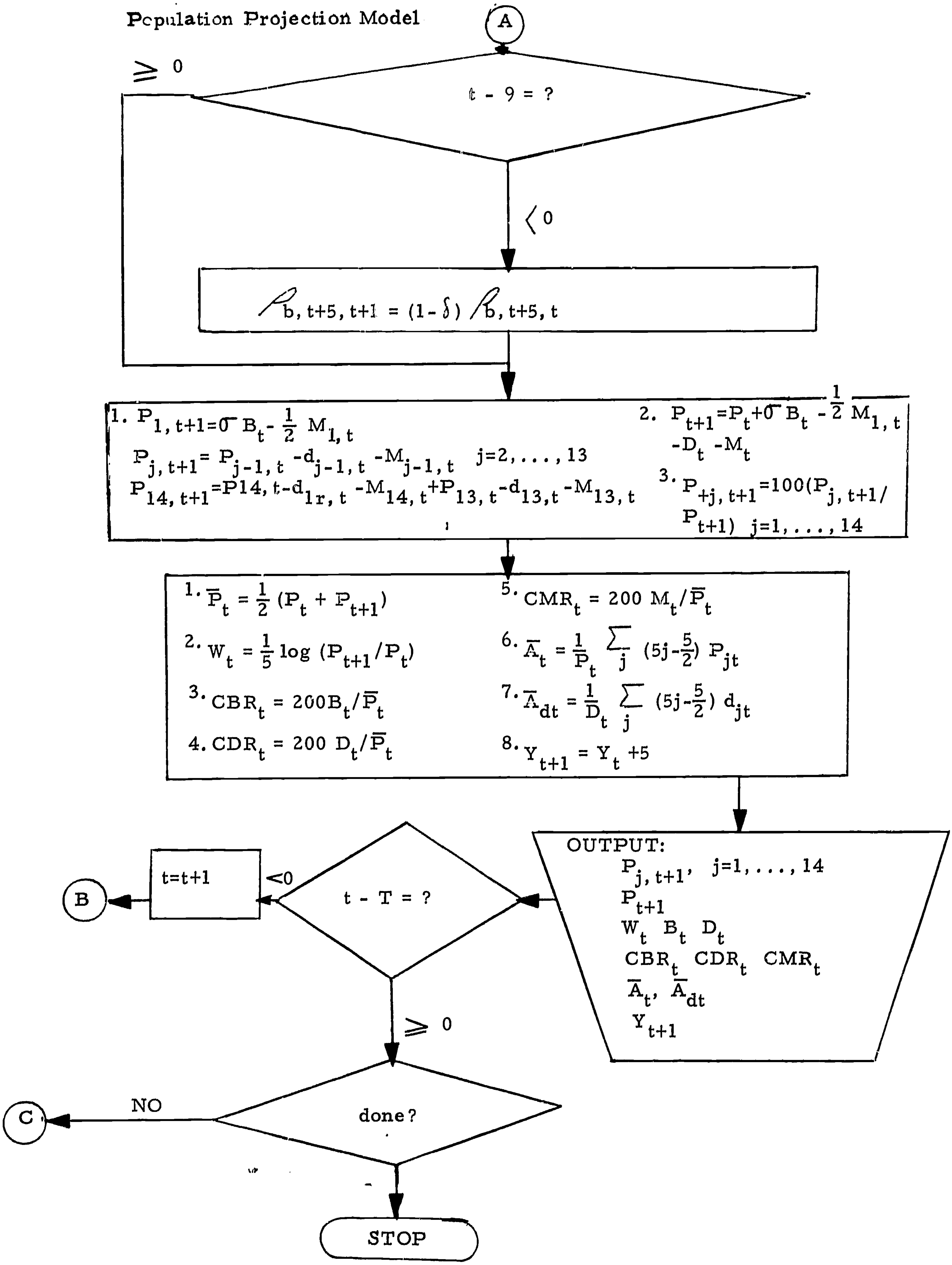
2b.) $m_{jt} = r_{mj} P_{jt}$

3b) $M_t = \sum_{j=1}^{14} m_{jt}$

4b) $d_{jt} = r_{dj} P_{jt},\ j = 2, \ldots, 14$

(A)

Population Projection Model



## ENROLLMENT PROJECTION MODEL

The model receives as input the necessary trends and initial conditions; projects the trends over the desired time period, beginning at the specified initial state; and provides as output the enrollment in each school grade at the end of each five-year period.

### OUTPUTS

The output emerges as a table of enrollments. The columns of the table represent school grades, and the rows correspond to the years of interest:

ENROLLMENTS:

| Grade<br>Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 . . . |
|---|---|---|---|---|---|---|---|---|---|
| 1971 | 30 | 632 | 646 | 619 | 601 | 584 | 581 | 562 | 540 . . . |
| 1976 | 32 | 641 | 661 | 633 | 610 | 597 | 593 | 577 | 551 . . . |
| . | . | . | . | . | . | . | . | . | . . . . |
| . | . | . | . | . | . | . | . | . | . . . . |
| . | . | . | . | . | . | . | . | . | . . . . |

### INPUTS

The model requires as input:

--the age distribution $P_{jt}$ of the school-age segment of the population, bu five-year age groups, projected over an arbitrary number of five-year intervals, as provided by the Population Projection Model; this is a matrix of dimensions 5 x T, where T is the number of intervals over which the population distribution is projected.

--the initial distribution $n_{ik0}$ of pupils by age in the school grades, by one-year age groups; this is a 20 x 14 matrix, whose rows are the ages from 3 through 22 and whose columns are the school grades 0 through 13 (Grade 0 is pre-kindergarten; Grade 13 is post-high school). This matrix should usually be supplied from averages of several years' distributions.

--assumed trends $D_{ik}$ in age populations in the school grades: the numerical change in the enrollment of each age group in each grade, whether planned or empirically determined. This is another 20 x 14 matrix. If no nonzero elements are introduced into $D_{ik}$, the model will project the initial population proportions without change.

--the number T of five-year projection intervals desired.

PROCESS

The model:

--uses linear interpolation to transform the crude input age distribution by five year age groups $P_{jt}$ into an estimated age distribution by single years $p_{it}$. The 5 x T input matrix thus becomes a 20 x T matrix. This operation runs the risk, especially in small populations, of assigning to one age population units which should properly be assigned to a neighboring age, thus creating a spuriously smooth distribution. The model introduces a partial correction for this difficulty should it arise.

--divides each initial age population $n_{ik0}$ in each grade by the estimated total population component $p_{i0}$ of the same age, obtaining $q_{ik0}$, the estimated initial proportion of children of age i enrolled in school in class k.

--outputs the 20 x 14 matrix $q_{ik0}$ as a check on the accuracy of input

--scans the matrix $q_{ik0}$ to see if any proportion is indicated as greater than unity. This could happen, for example, if the population included considerably more 8-year-olds than 7- or 9-year-olds. The input age distribution would not indicate this fact but would supply only the total population between age 5 and age 9. The linear interpolation would therefore understate age 8 and overstate ages 7 and 9. If nearly 100 percent of the 8-year-olds happened to be enrolled in Grade 3, the actual enrollment could exceed the estimated population, whereupon the model would simply average the proportions for ages 7, 8, and 9 and assign the average value to the three age groups in the school grade affected. If such an adjustment should prove necessary, the model would output the entire revised matrix of proportions $q_{ik0}$ before proceeding.

--adjusts the proportion matrix to incorporate any assumed trends in enrollment such as might be realized by recruitment programs, changes in promotion policy, or unknown but observed causes. This adjustment is computed in such a way that a trend which the user indicates as a constant initial upward trend is simulated as exponentially asymptotic to the limiting value $q_{ikt}=1.0$, thus reflecting the fact that it is harder to push a phenomenon such as enrollment from 95 percent to 99 percent than from, say, 45 percent to 49 percent. Short trends, such as discontinuous policy changes, can be simulated by introducing only a single time period's population data for a short run, and then changing the trends and making a longer run.

--multiplies each resulting enrollment proportion $q_{ikt}$ by the corresponding projected population component $p_{it}$ and sums over all age groups to obtain the estimated total enrollments by school class.

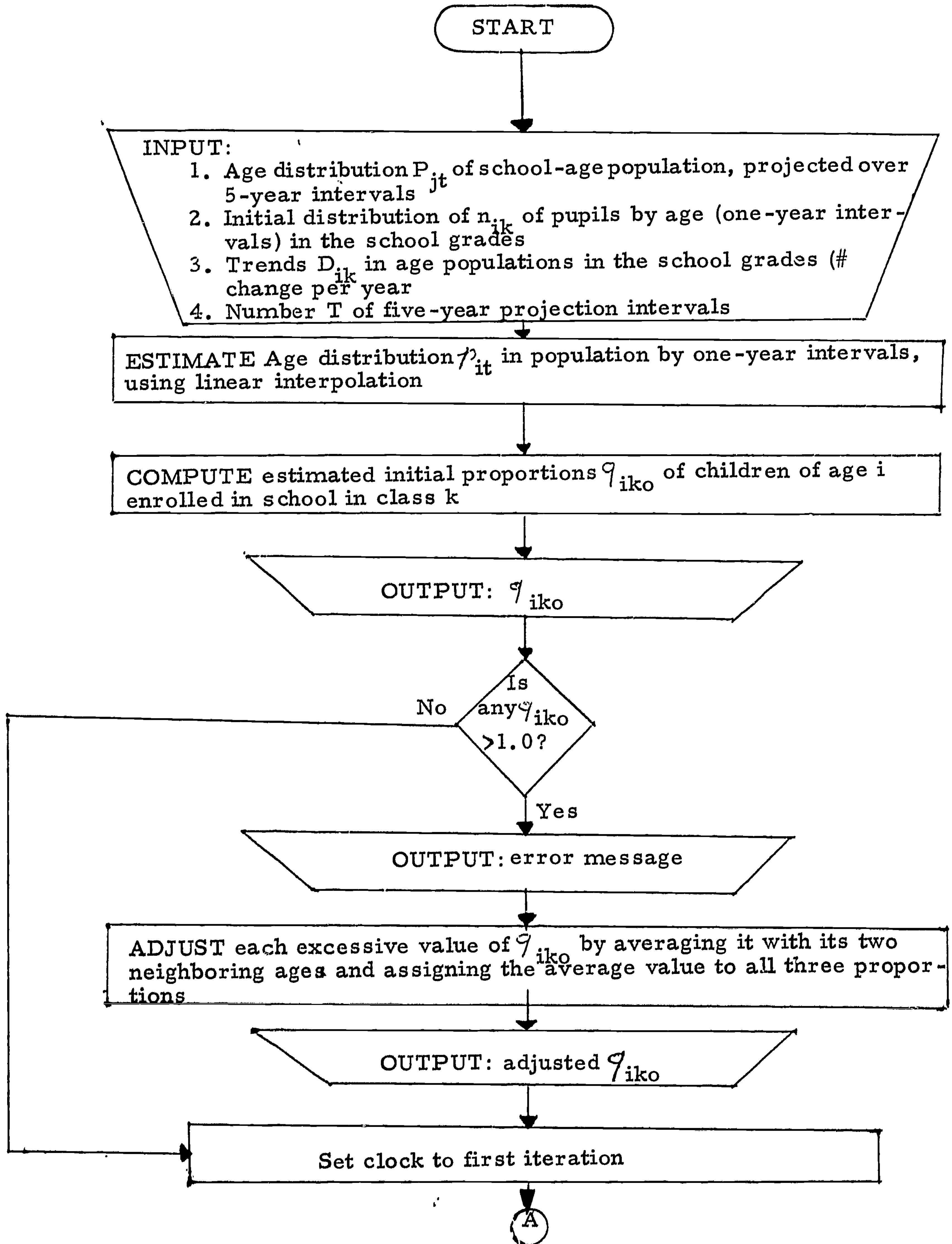
## ENROLLMENT PROJECTION MODEL

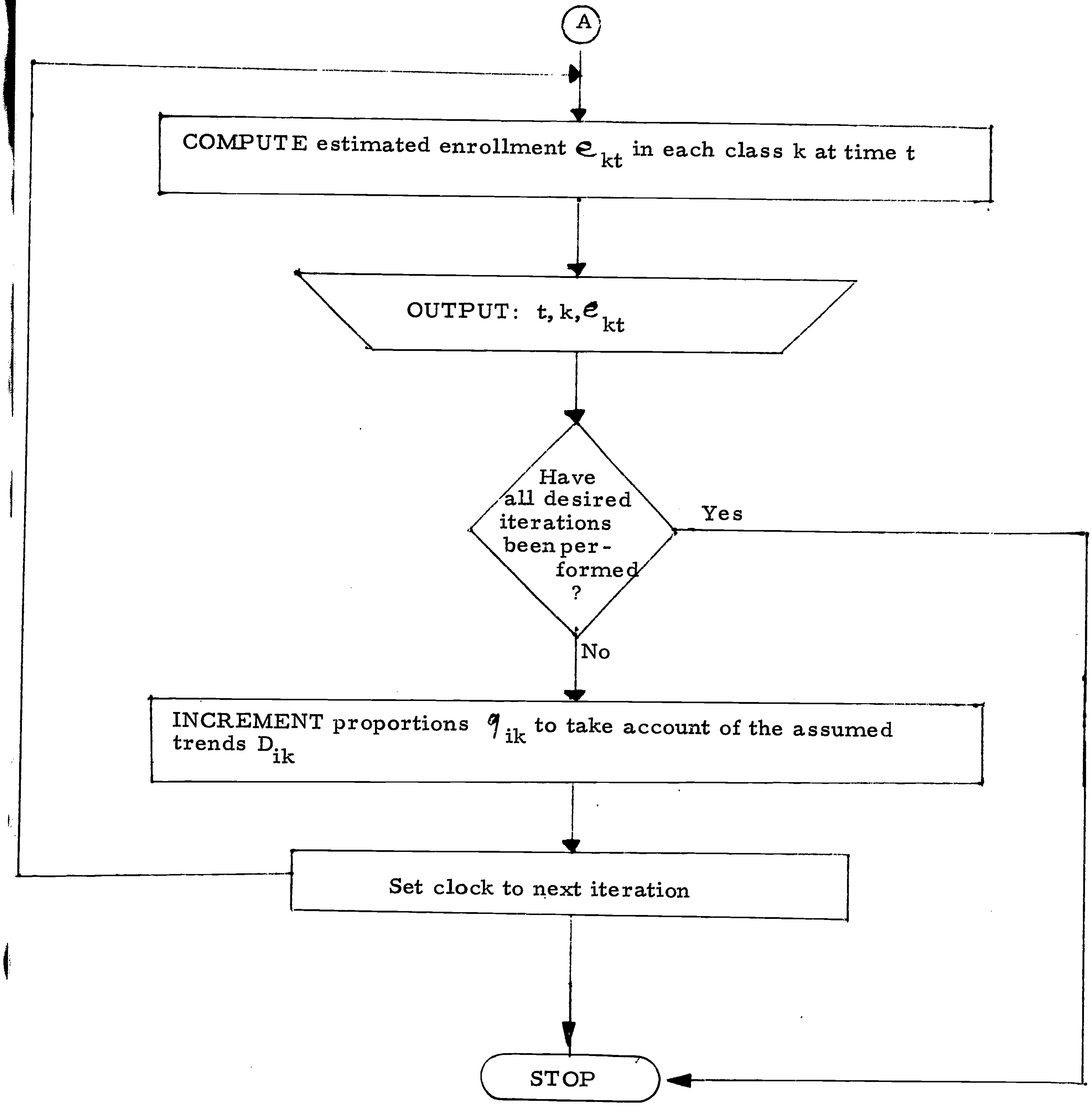
### Variable List and Equations

| Variable | | Defining Equation |
|---|---|---|
| $D_{ik}$ | Trend in enrollment of children of age i in class k (children per year) | Given |
| $e_{kt}$ | Enrollment in class k at the beginning of the five-year interval t (children) | $e_{kt} = \sum_i p_{kt}\, q_{ik}$ |
| i | Age index (years) | $3 \le i \le 22$ |
| j | Age group index by five-year groups (five years) | $1 \le j \le 5$ |
| k | School class index (dimensionless) | $0 \le k \le 13$ |
| $n_{ik}$ | Initial number of pupils of age i enrolled in class k (children) | Given |
| $p_{it}$ | Estimated population of age i at time t (children) | $p_{it} = \frac{1}{5}\left[P_{jt} + \frac{1}{5}(i - 5j + 3)(P_{j+1,t} - P_{jt})\right]$<br>$i = 5j-2, \ldots 5j+2, \quad j = 1, \ldots, 4, \quad t = 1 \ldots T$ |
| $P_{jt}$ | Projected population of age group j at time t (children) | Given |
| $q_{ikt}$ | Estimated proportion of children of age i enrolled in class k at time t (dimensionless) | $\begin{cases} q_{ik0} = n_{ik}/p_{i0} \\ q_{ik,t+1} = q_{ikt}\left(\frac{p_{it}}{p_{i,t+1}}\right) + 5\frac{D_{ik}}{p_{i,t+1}}\left(\frac{1-q_{ikt}}{1-q_{ik0}}\right) \end{cases}$ |
| t | Time index, by five-year periods (five years) | $0 \le t \le T$ |
| T | Number of five-year periods in the current projection (five years) | Given |

## ENROLLMENT PROJECTION MODEL

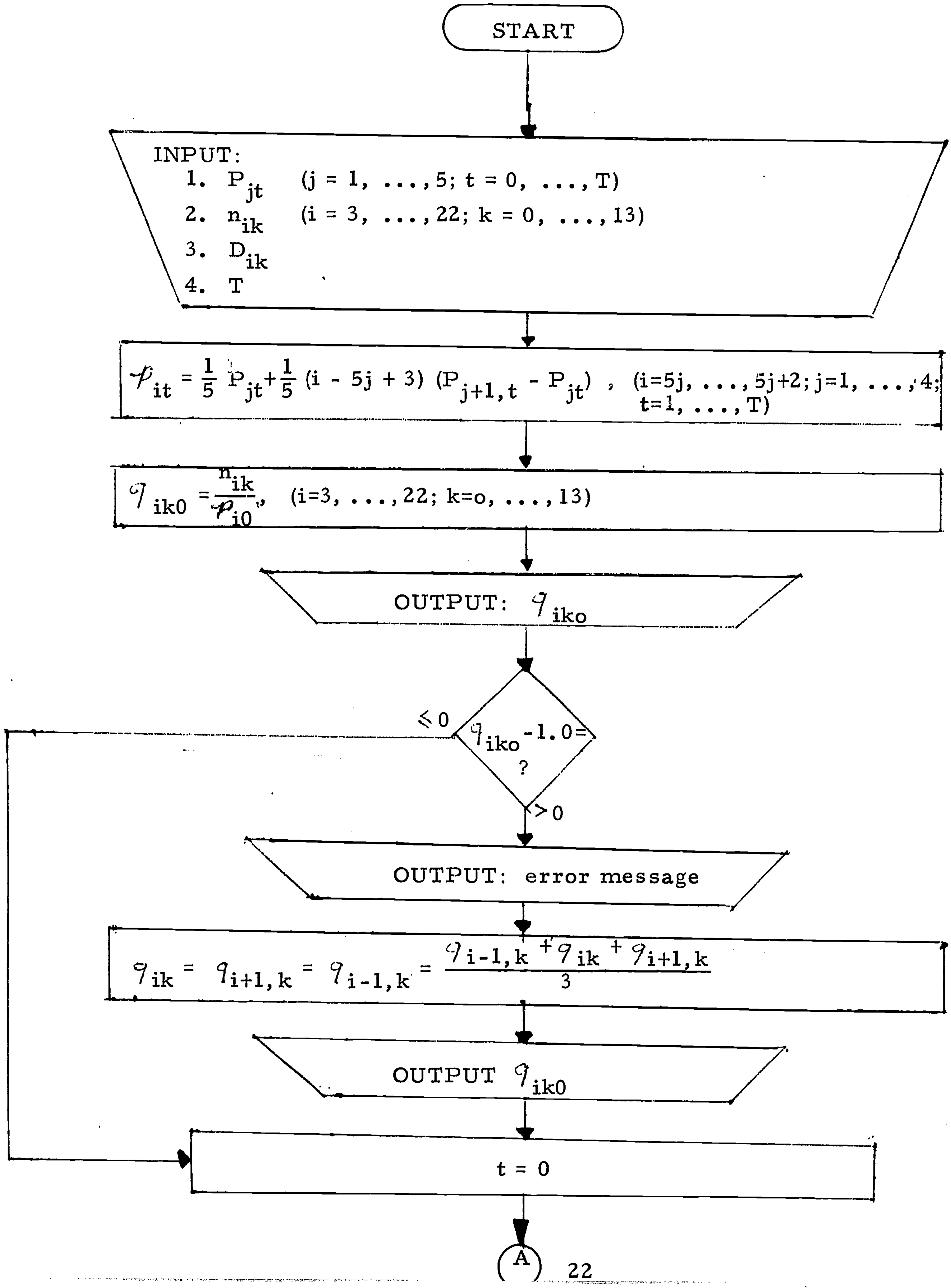
### English Language Flowchart



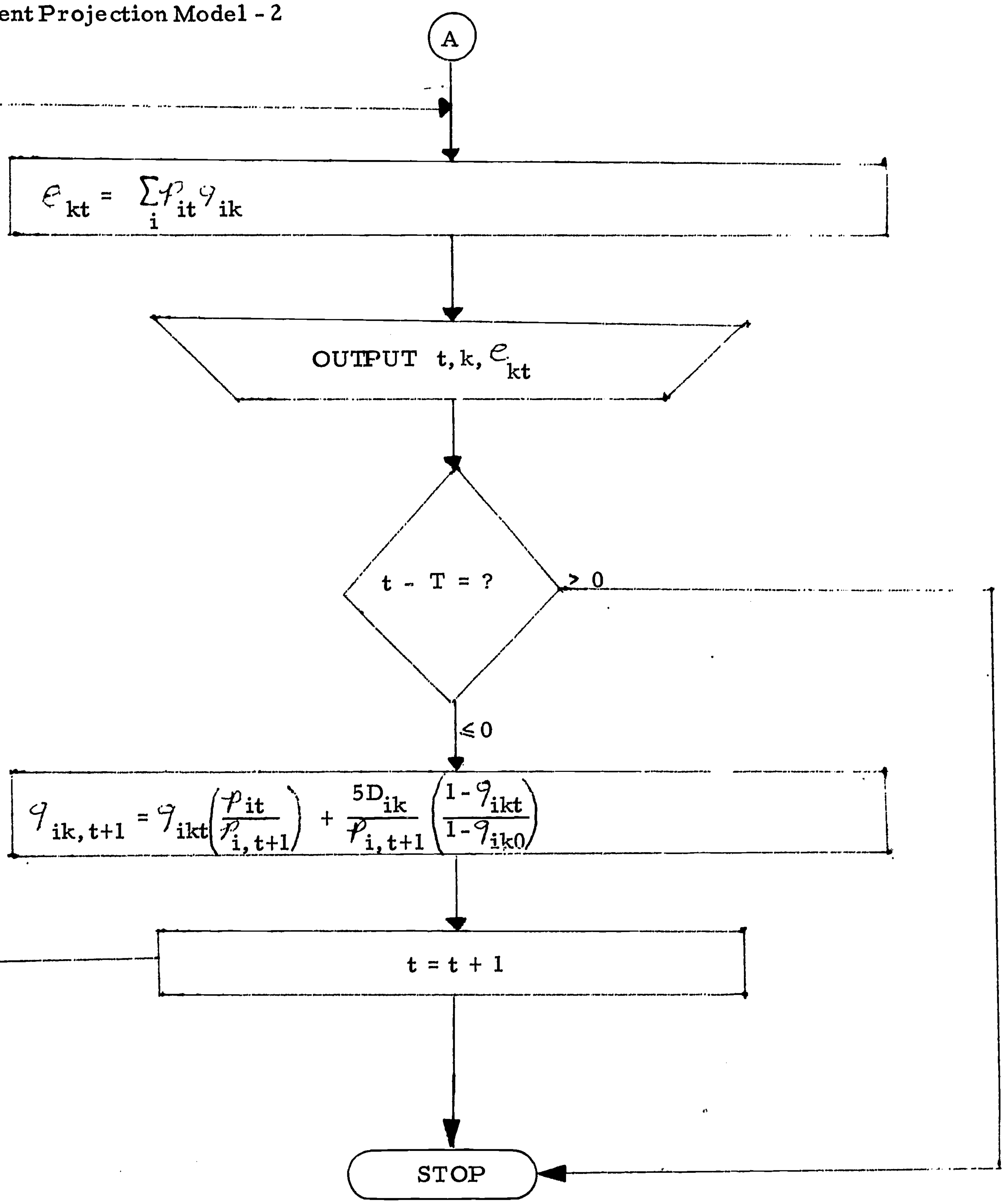

A
COMPUTE estimated enrollment $e_{kt}$ in each class k at time t
OUTPUT: t, k, $e_{kt}$
Have all desired iterations been performed ?
Yes
No
INCREMENT proportions $q_{ik}$ to take account of the assumed trends $D_{ik}$
Set clock to next iteration
STOP

ENROLLMENT PROJECTION MODEL

Detailed Mathematical Flowchart



Enrollment Projection Model - 2



## Chapter III

## Facilities Planning Model

### DESCRIPTION OF OBJECTIVES

The Facilities Planning Model attempts to predict the facilities needs in future years at areas, agency, and Bureau levels. It is important to know future facilities needs so that budgeting, planning, and construction may be completed in sufficient time to prevent shortages from occurring.

In this way planners at each level can efficiently anticipate the demands of a changing Indian population.

The Facilities Planning Model uses several types of data, including information on present facilities and enrollments; on the increases necessary to bring the present facilities to minimally acceptable level, where they are inadequate at present; and on future enrollments. These inputs are combined to produce a detailed list of the facilities necessary for future years.

The model enables the user to examine a large number of components and to project the components in a variety of ways. The input which describes the increases necessary in the present facilities can be used in a number of ways. For example, if a planner, to implement the intensification of a language program, wants to increase the number of language laboratories per student, he can study the long-term effects of his decision on the future demand for language laboratories by manipulating the parameters describing the increases over the present laboratory facilities. The model will project not only the number of language labs, based on present levels, but also the number based on hypothetical increases.

The model has another subsidiary benefit; in gathering the data for the model, the BIA will obtain a complete inventory of their present facilities.

Model outputs, inputs, and processes are discussed following the conceptual flow chart in this section; a variable list and English language and mathematical flow charts are included in Appendix E.

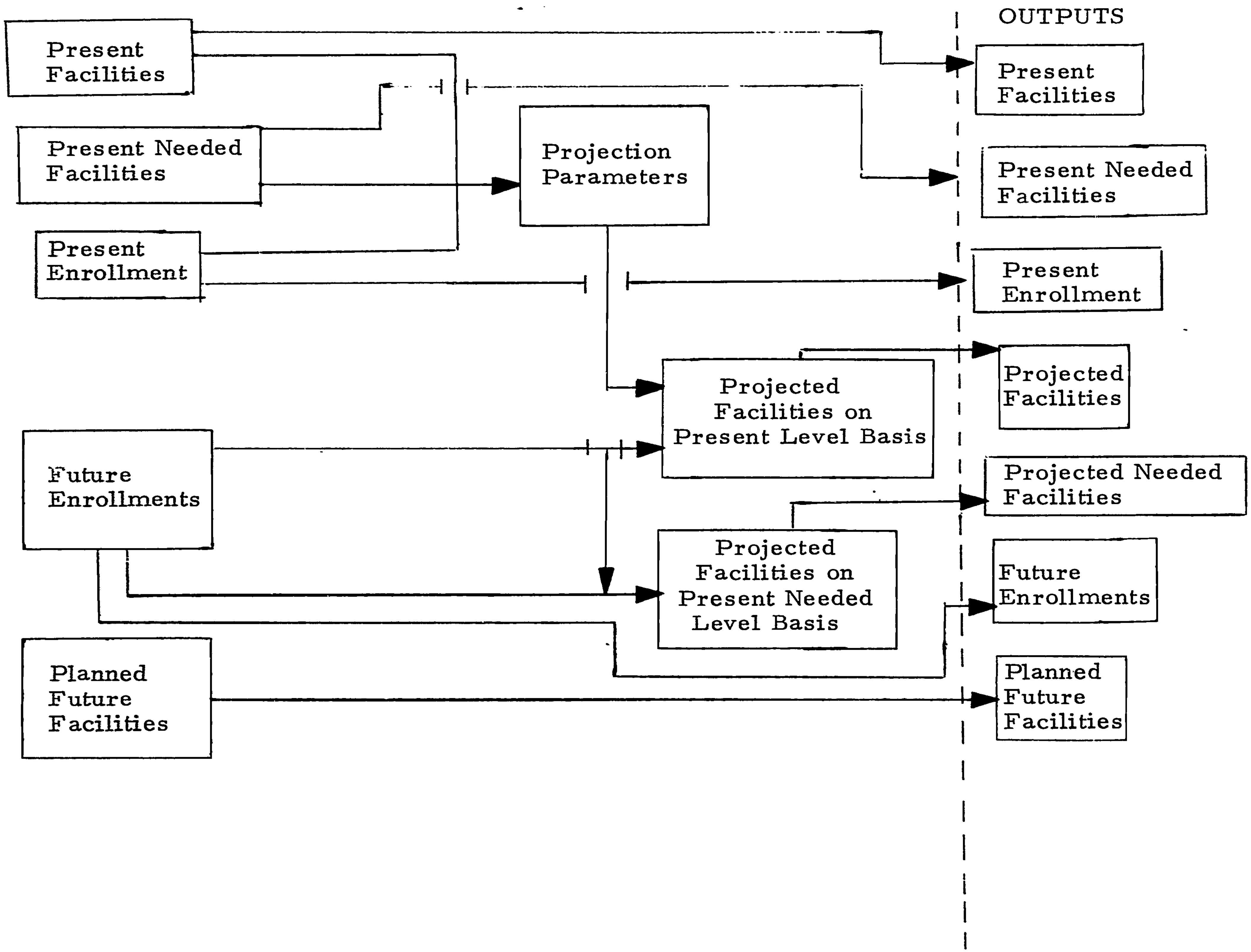
## OUTPUTS

A sample output page for the Facilities Planning Model is presented on the following page. Output of this type will be printed for each area, each agency, and for the entire BIA. The output can be printed for each school, if so desired.

The output will state the area and agency (a listing by school is optionally available for present facilities) and the year for which the projection is being made. A list of types of facilities for each grade is presented. The entries in this matrix are the amounts (either in numbers of units or square feet of space) of each facility type for each grade. The output is presented both for the present inventory of facilities, and for the projected inventory. As was discussed earlier, the projection is made both on the basis of the present ratio of facilities to enrollment, and on the basis of a hypothetical future ratio. The facilities planned by the BIA are added to the present facilities and the resulting total is a further output. Thus, for any given area, the planner will have at his disposal a comprehensive set of information about present, planned, and needed facilities. He will be able, therefore, to adjust his budget and correct any errors in planning. It should be noted that the Facilities Planning Model treats the area as its finest level of detail. The distribution of these facilities into schools is accomplished by the Facilities Location Model.

It should be noted that the Facilities Planning Model provides projections at the area level, but not at that of the individual school.

## BIA FACILITIES PLANNING MODEL



AREA 3, AGENCY 5 YEAR - 1975

PROJECTED FACILITIES

GRADE

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Regular Classrooms | 21 | 17 | 20 | 26 | 23 | 21 | 17 | 23 | 27 | 29 | 25 | 22 |
| Science Classrooms | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 3 | 7 | 6 | 5 | 8 |
| Science Lab. Rooms | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | 5 | 3 | 2 |
| Combination Science Classroom-Labs. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| Language Lab. Rms. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 5 | 8 | 12 |
| Home Econ. Rooms | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 7 | 6 | 7 | 5 |
| Sec. Practice Rms. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 |
| Office Practice Rms. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Typing Rooms | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 |
| Art Rooms | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 5 | 4 | 4 | 5 |
| Agriculture Rooms | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 2 | 3 | 5 | 7 |
| Mech. Drawing Rms. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Shop (Ind. Art) Rms. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| Shop (Voc.) Rooms | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Music Rooms | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 2 | 3 | 3 | 2 |
| Spec. Clsrms. for Excep. Children | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| Other Spec. Clasrms. | 0 | 0 | 0 | 3 | 0 | 3 | 2 | 1 | 0 | 0 | 1 | 3 |
| School Lib. Areas | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| Study Halls | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 2 | 1 |
| Auditoriums | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| Cafe. of Lunchrm. | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| Cafe. - Aud. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gym - Aud. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gym - Cafe. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gym-Cafetorium | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gymnasiums | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 |
| Swimming Pools | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| Total Teach. Sta. for Phys. Ed. | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 1 | 1 | 2 |
| Audio-Visual Rms. | 1 | 1 | 2 | 3 | 1 | 3 | 2 | 1 | 1 | 3 | 3 | 4 |
| Multi-Purpose Rms. | 3 | 3 | 1 | 3 | 2 | 1 | 3 | 5 | 1 | 1 | 5 | 2 |
| Misc. Instructional Areas | 4 | 3 | 1 | 5 | 3 | 2 | 3 | 1 | 5 | 6 | 3 | 5 |
| Dorm. Rooms | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 27 | 53 | 75 | 81 | 68 |
| Lounge | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 1 | 2 | 2 | 2 |
| Student Unions | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| Staff Quarters | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Health Services | 1 | 1 | 1 | 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Admin. Room | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 3 | 3 | 2 |
| Bath/Rest Rooms | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 3 | 6 | 5 | 4 |
| Other | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 5 | 3 | 5 | 3 | 6 |

## INPUTS

Inputs to the Facilities Planning are detailed, but basically very simple. They include: a list of present facilities; a list of present enrollments; a list of needed (or desired) increases in the present facilities; the target year of the projection; and the student population during the target year.

A proposed list of facilities is presented in the sample output. Specific items can without difficulty be added, changed, or deleted. The input parameters are described in more detail in Appendix E.

## PROCESS

The process which the model uses to accomplish the projection is described in complete detail in Appendix E. A short description will be presented here for the reader who is not concerned with mathematical or structural detail.

The model uses the ratio of present facilities to present student population to make its projections. It simply multiplies this ratio by the projected population (from the Population Projection Model) to obtain a new level of facilities. It is assumed that the ratio will remain constant in future years. The user may avoid this assumption by supplying the model with expected increases in the present facilities, to adjust the ratio to that which will probably be in effect during the target year. In this way, allowance may be made for the changing intensity of programs.

The Model collects and prints the present facilities, enrollments, and the present facilities with increases. It computes the ratios, reads in the population for the target year, multiplies it by the ratios to obtain the projected facilities, and then prints the projected facilities. This is repeated for each target year.

## BIA FACILITIES PLANNING MODEL

### Variable List

Input Variables:

| | |
|---|---|
| $F_{i,j,K,M,L}$ | Present facility L (see Section 4.2.4, Sample Output) for grade M, school K, area j, agency i |
| $ENROL_{i,j,K,M}$ | Present enrollment in grade M, school K, area j, agency i |
| $DF_{i,j,K,M,L}$ | The change in facility L to bring it up to a present desired level, or the change to reflect some future level not the same as present (e.g., in future, one desires to have 5 classrooms instead of the present 4 for grade 3 — $DF_{i',j',K',L'} = +1$) for grade M, school K, area J, agency i |
| Y | The year to which the projection is being done |
| $ENAP_{i,j,M}$ | The enrollment in year Y, grade M, area j, agency i |
| YMAX | The last year extrapolated to |
| jMAX(i) | The number of areas in agency i |
| IMAX | The number of agencies |

Output Variables:

| | |
|---|---|
| $FA_{i,j,M,L}$ | Present facility L, grade M, area j, agency i |
| $FAD_{i,j,M,L}$ | Present needed facility L (see FD), grade M, area j, agency i |
| $ENA_{i,j,M}$ | Present enrollment grade M, area j, agency i |
| $FAG_{i,M,L}$ | Present facility L for grade M, agency i |
| $FAGD_{i,M,L}$ | Present needed facility L, grade M, agency i |
| $ENAG_{i,M}$ | Present enrollment, grade M, agency i |
| $FB_{M,L}$ | Present facility L for grade M for the whole BIA |
| $FBD_{M.L}$ | Present needed facility L, for grade M for the whole BIA |
| $ENB_{M}$ | Present enrollment in grade M for the whole BIA |
| $FPA_{i,j,M,L}$ | Projected facility L, grade M, area j, agency i, year Y |

BIA Facilities Planning Model
Output Variables -- cont.

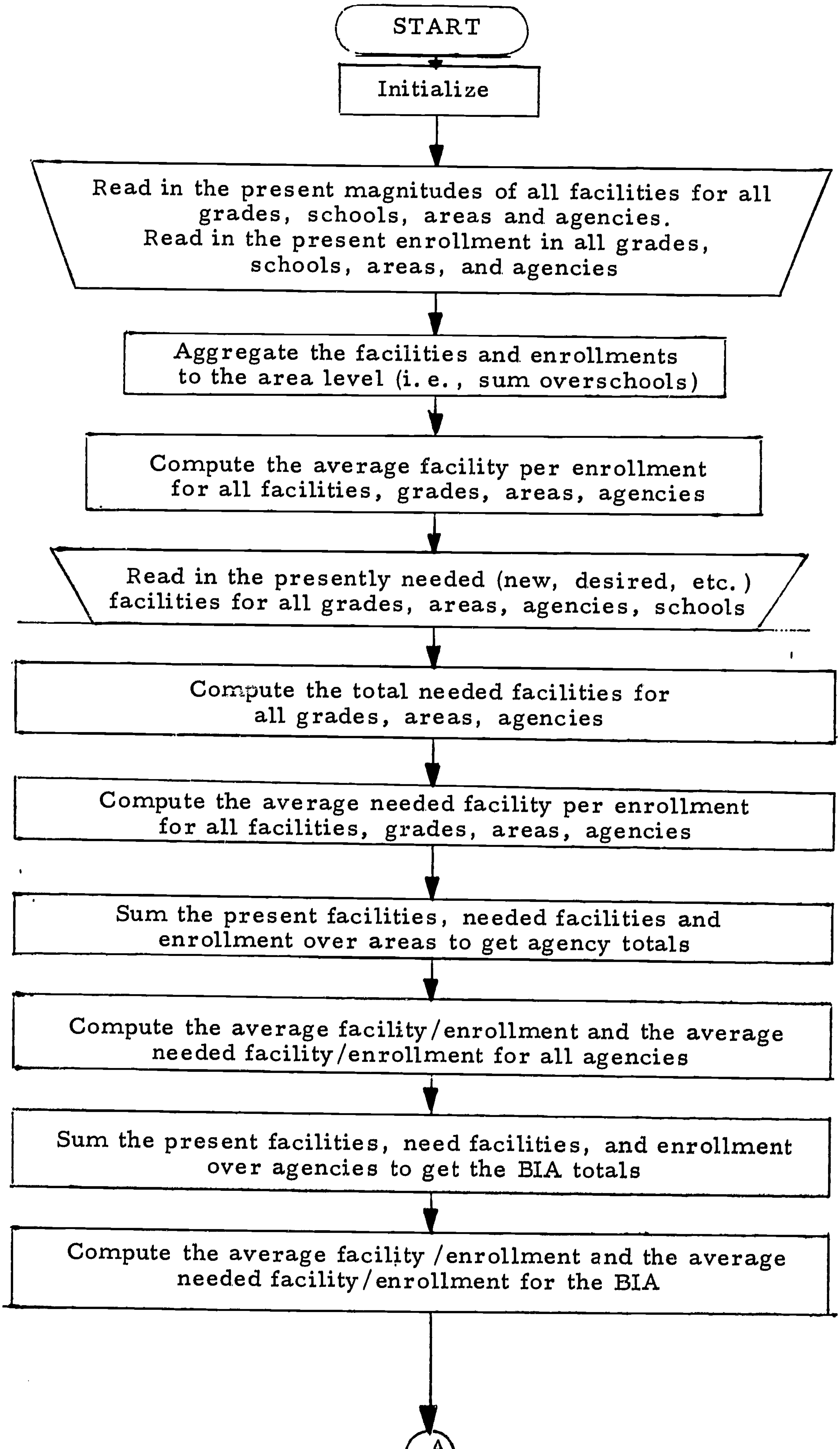
| | |
|---|---|
| $FPAD_{i,j,M,L}$ | Projected needed facility L, grade M, area j, agency i, year Y |
| $ENAP_{i,j,M}$ | Projected enrollment, grade M, area j, agency i, year Y |
| $FPAG_{i,M,L}$ | Projected facility L, grade M, agency i, year Y |
| $FPAGD_{i,M,L}$ | Projected needed facility L, grade M, agency i, year Y |
| $ENAGP_{i,M}$ | Projected enrollment, grade M, agency i, year Y |
| $FPB_{M,L}$ | Projected facility L, grade M, year Y, total BIA |
| $FPBD_{M,L}$ | Projected needed facility L, grade M, year Y, total BIA |
| $EPNB_{M}$ | Projected enrollment, grade M, year Y |
| Y | The target year of the projection |

Intermediate Variables:

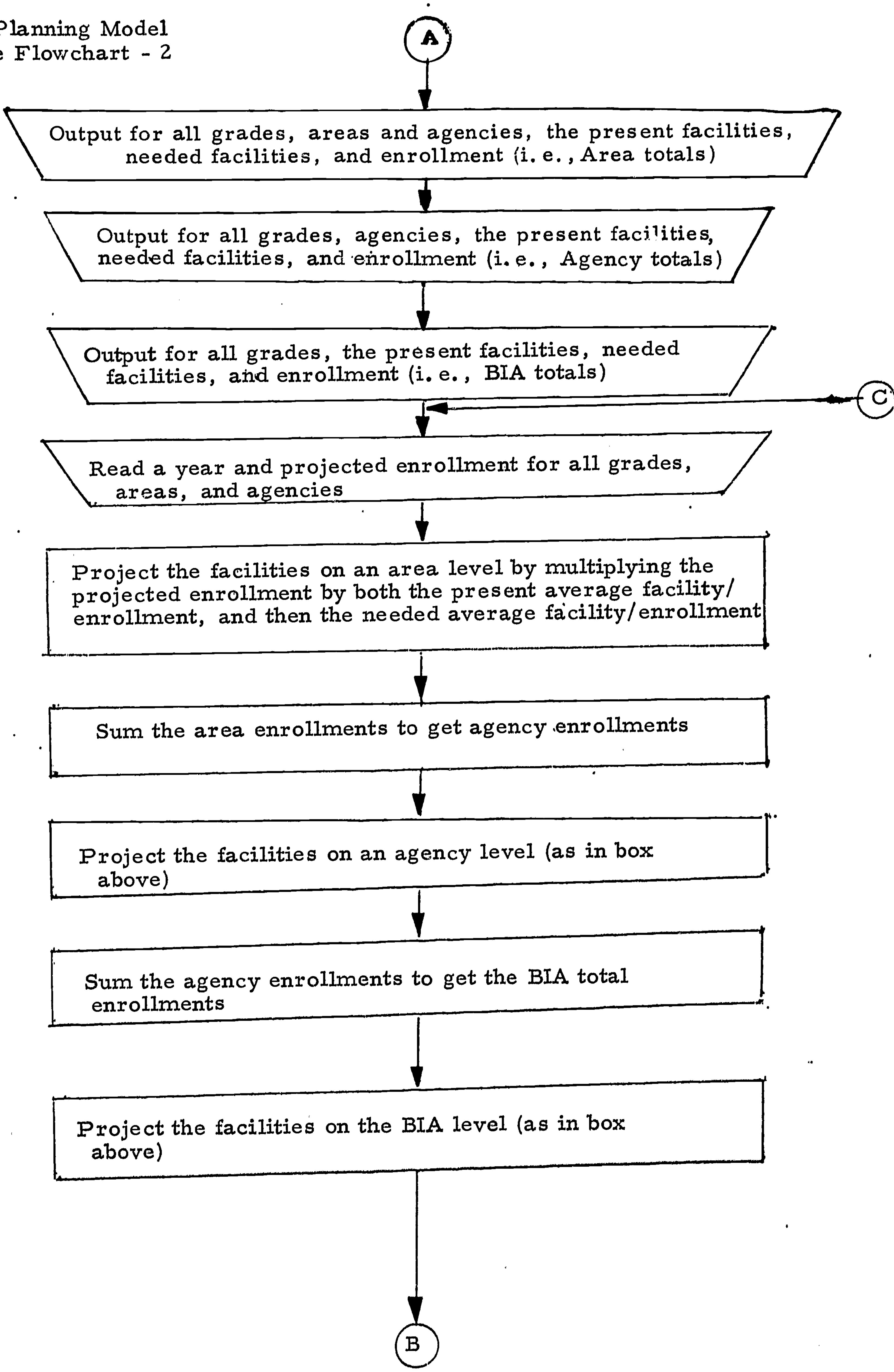
| | |
|---|---|
| $CAR_{i,j,M,L}$ | Projection constant, present level, on the area |
| $CARD_{i,j,M,L}$ | Projection constant, needed level, on the area |
| $CAG_{i,M,L}$ | Projection constant, present level, on the agency |
| $CAGD_{i,M,L}$ | Projection constant, needed level, on the agency |
| $CB_{M,L}$ | Projection constant, present level, on the BIA |
| $CBD,_{M,L}$ | Projection constant, needed level, on the BIA |

FACILITIES PLANNING MODEL

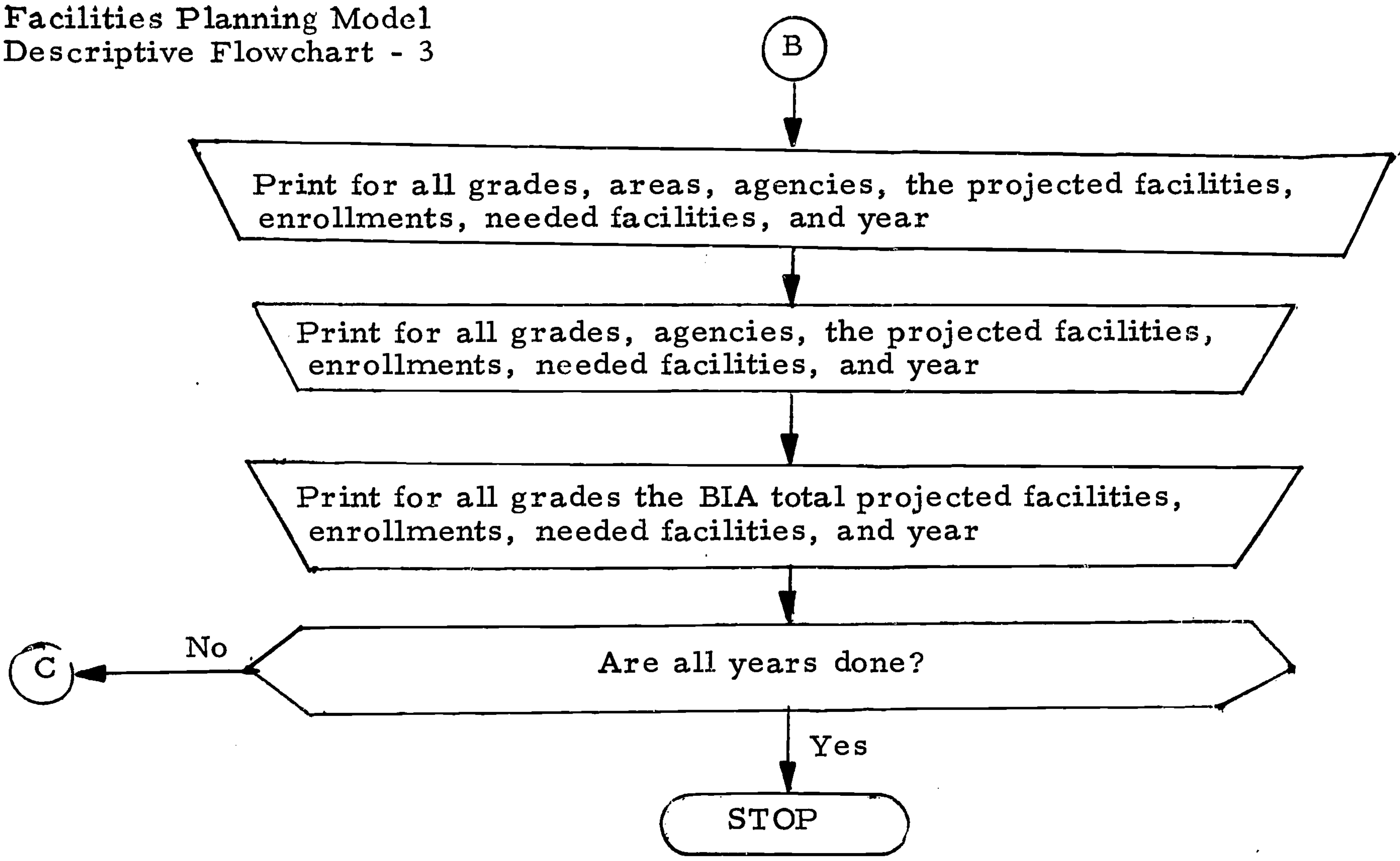
English Language Flowchart



Facilities Planning Model
Descriptive Flowchart - 2

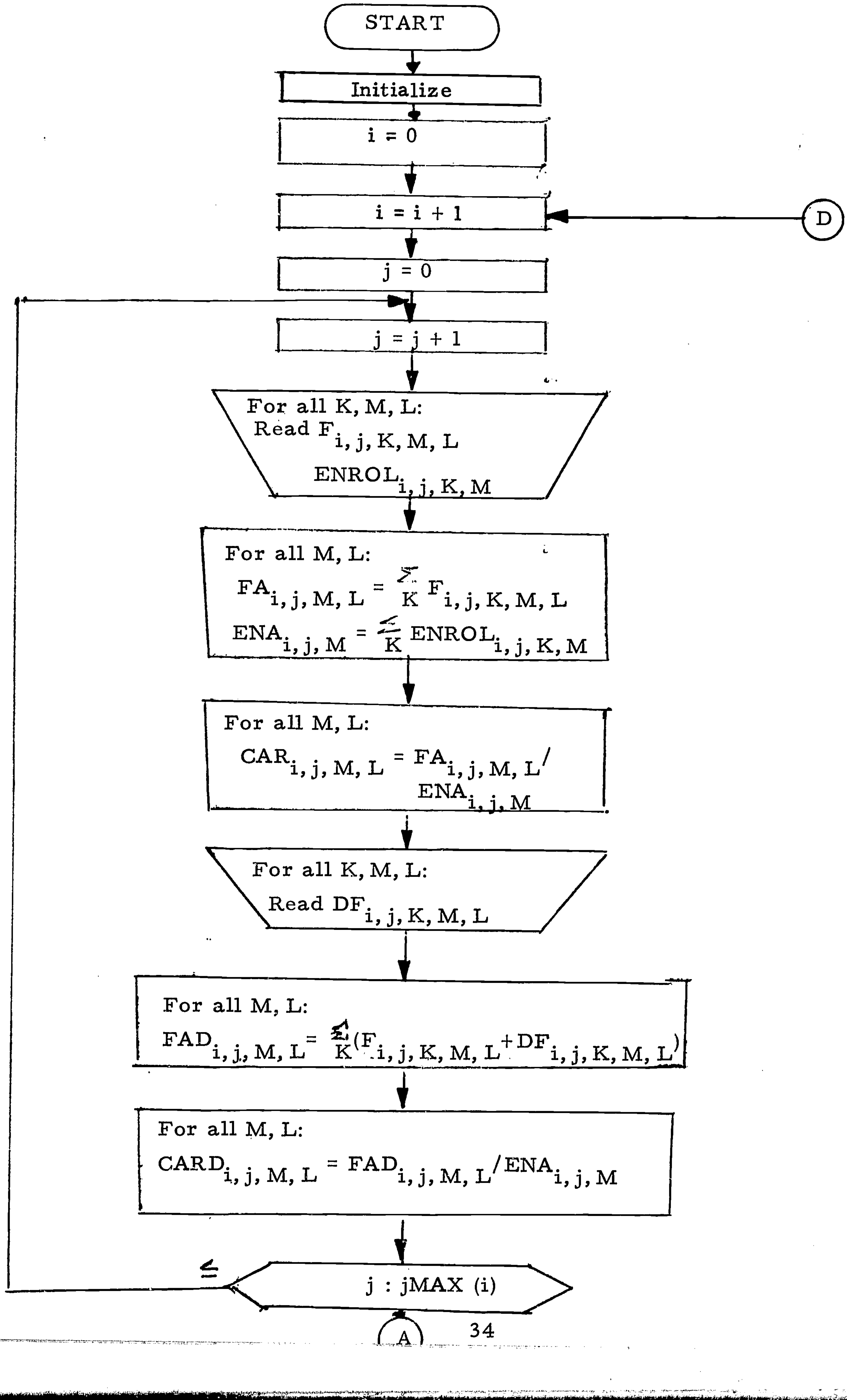


Facilities Planning Model
Descriptive Flowchart - 3



BIA FACILITIES PLANNING MODEL

Mathematical Flowchart



BIA Facilities Planning Model
Mathematical Flowchart - 2

A

For all M, L:

$$FAG_{i,M,L} = \sum_{j} FA_{i,j,M,L}$$

$$ENAG_{i,M} = \sum_{j} ENA_{i,j,M}$$

$$FAGD_{i,M,L} = \sum_{j} FAD_{i,j,M,L}$$

For all M, L:

$$CAG_{i,M,L} = FAG_{i,M,L}/ENAG_{i,M}$$

$$CAGD_{i,M,L} = FAGD_{i,M,L}/ENAG_{i,M}$$

$i : iMAX$

$\leq$

$>$

For all M, L:

$$FB_{M,L} = \sum_{i} FAG_{i,M,L}$$

$$ENB_{M} = \sum_{i} ENAG_{i,M}$$

$$FBD_{M,L} = \sum_{i} FAGD_{i,M,L}$$

For all M, L:

$$CB_{M,L} = FB_{M,L}/ENB_{M}$$

$$CBD_{M,L} = FBD_{M,L}/ENB_{M}$$

For all i, j, M, L: Print

$FA_{i,j,M,L}$, $FAD_{i,j,M,L}$

$ENA_{i,j,M}$

B

B

For all i, M, L: Print
$FAG_{i,M,L}$, $FAGD_{i,M,L}$
$ENAG_{i,M}$

For all M, L: Print
$FB_{M,L}$, $FBD_{M,L}$
$ENB_{M}$

E

For all i, j, M:
Read Y, $ENAP_{i,j,M}$

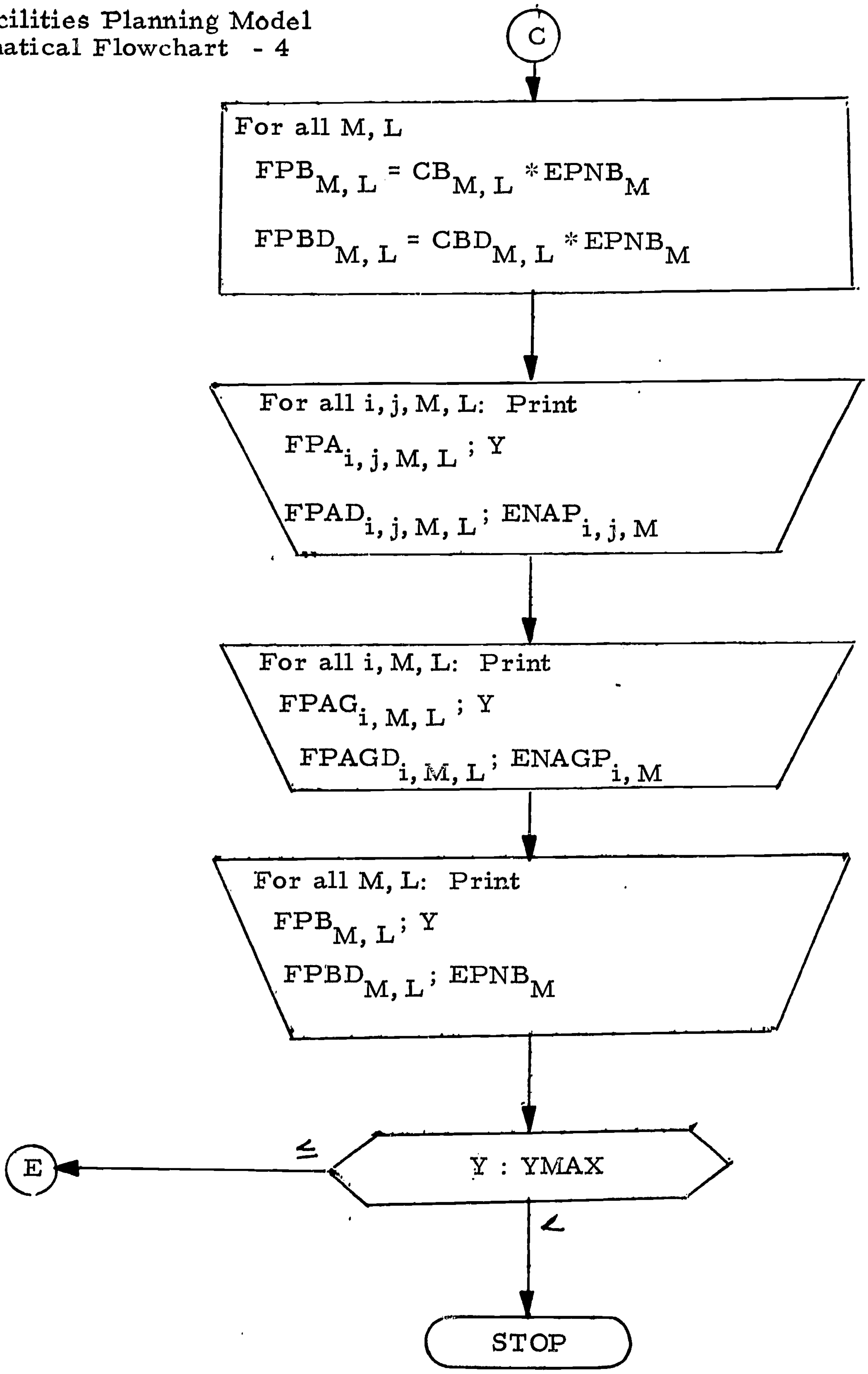
For all i, j, M, L
$$FPA_{i,j,M,L} = CAR_{i,j,M,L} * ENAP_{i,j,M}$$
$$FPAD_{i,j,M,L} = CARD_{i,j,M,L} * ENAP_{i,j,M}$$

For all i, M
$$ENAGP_{i,M} = \sum_{j} ENAP_{i,j,M}$$

For all i, M, L
$$FPAG_{i,M,L} = CAG_{i,M,L} * ENAGP_{i,M}$$
$$FPAGD_{i,M,L} = CAGD_{i,M,L} * ENAGP_{i,M}$$

For all M
$$EPNB_{M} = \sum_{i} ENAG_{i,M}$$

C


C
For all M, L
$FPB_{M,L} = CB_{M,L} * EPNB_M$
$FPBD_{M,L} = CBD_{M,L} * EPNB_M$
For all i, j, M, L: Print
$FPA_{i,j,M,L}$; Y
$FPAD_{i,j,M,L}$; $ENAP_{i,j,M}$
For all i, M, L: Print
$FPAG_{i,M,L}$; Y
$FPAGD_{i,M,L}$; $ENAGP_{i,M}$
For all M, L: Print
$FPB_{M,L}$; Y
$FPBD_{M,L}$; $EPNB_M$
Y : YMAX
≤
E
<
STOP

# Chapter IV

## Economic Projection Model

### DESCRIPTION OF OBJECTIVES

The primary function of the BIA Economic Projection Model is to provide information which can be used by the BIA to determine where to locate new school facilities. The differential benefits of alternative locations in an Indian Area for 81 industry types are therefore examined. This method isolates the specific locations which are most desirable for industries and thus predicts where increased concentrations of population will occur, should industry actually locate within the area. The School Facilities Location Model (see Section 4.2.4) uses this and other information to suggest means of improving the allocation of school facilities.

The second objective of the model is to provide information for use by the BIA and Indians in formulating industrial development plans for Indian areas. Although not directly related to educational needs, this is of long range importance for education; education programs may need to be modified to provide students with training for the jobs which industrial development can provide. Information is therefore provided as to the kinds of industry least hindered by financial constraints from location in an Indian Area. This information can be used as a partial basis for developing a strategy to attract industry to the area, and may itself be a means of persuading companies of the benefits of location in an area.

The Economic Projection Model can, however, be only a partial basis for an industrial development plan, for two major reasons. First, any such plan, to be successful, must take into account Indian preferences. Secondly, many other non-economic factors, among them the location of schools and other services, must be considered. An industrial development plan requires careful coordination with school facilities plans; schools serve an incentive for industrial location, but their facilities may not be adequate to accommodate the increased enrollment resulting from the location of new industry. Industrial development planning as such is not included as a formal component of the Economic Projection Model. However, because of the importance of development planning for school location, this interface is discussed later in this section under the heading Planning Subprocess. The following pages include a conceptual flow chart of the Economic Projection Model, a discussion of both formal outputs of the model, a sample of the formal output, and discussions of required inputs and process. A variable list and detialed flowcharts for the formal model are included in Appendix E.

OUTPUTS

The Economic Projection Model provides information about the total transportation costs for each of 81 industry types for each two mile by two mile square in a grid covering the entire Indian area (see chart on following page). This information may be compared with the mean amount spent on transportation by companies in each industry to give an indication of the savings or additional expense incurred by location at a specific grid square. In some industries ( generally those with high weight or bulk relative to value-added) transportation costs are minor compared to other costs. The importance of transportation for each of the industries is given by the Transportation Intensive Index, which represents the total amount spent on transportation, divided by the total value of all outputs in the industry. Similarly, in some industries, labor constitutes a high proportion of costs; a Labor Intensive Index is presented to reflect the importance of this locational factor. Finally, the grid map for each industry includes designation of proximity to towns of various sizes for each grid square.

These outputs are designed to provide information on the basis of which decisions for each industry type can be made; the relative importance of the transportation and labor costs is not estimated. Such information is to be used primarily by a company, of a particular industry type, which is considering location on the reservation. The company may take its own characteristics and needs into consideration, choose several locations which satisfy its transportation and labor needs, and then choose among feasible locations on the basis of secondary factors.

The information on individual industries is to be used by the

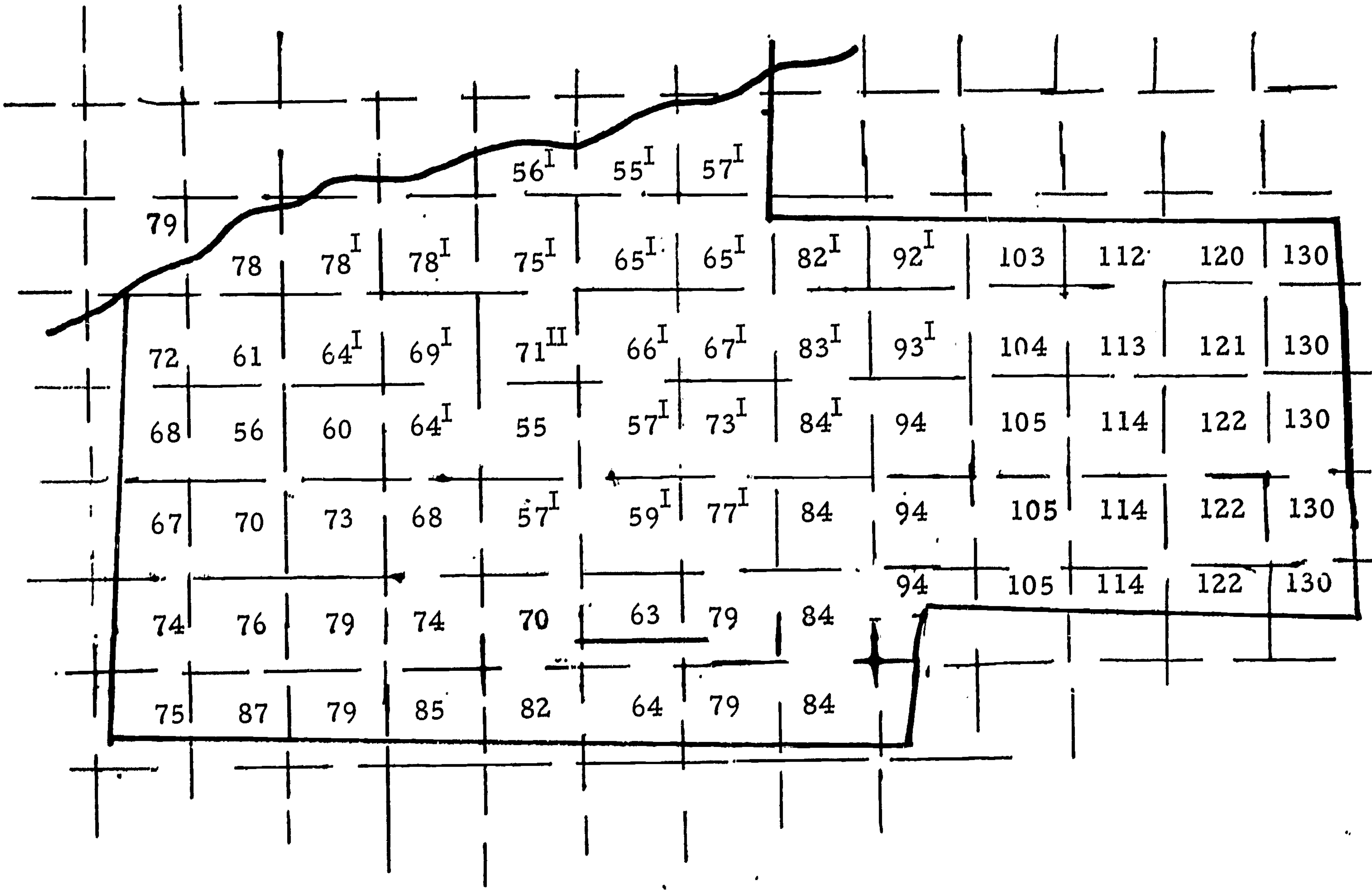
BIA ECONOMIC PROJECTION MODEL

SAMPLE OUTPUT

Industry Location Desirability Map

INDUSTRY: Paints and Allied Products

| | |
|---|---|
| Mean Yearly Transportation Cost for Companies in Industry . . . . . . . . . . . . . . . . . . . . . . . . . . | $49,000 |
| Index of Transport Intensiveness . . . . . . . . . . . | 0.07 |
| Index of Labor Intensiveness . . . . . . . . . . . . . . | 0.27 |

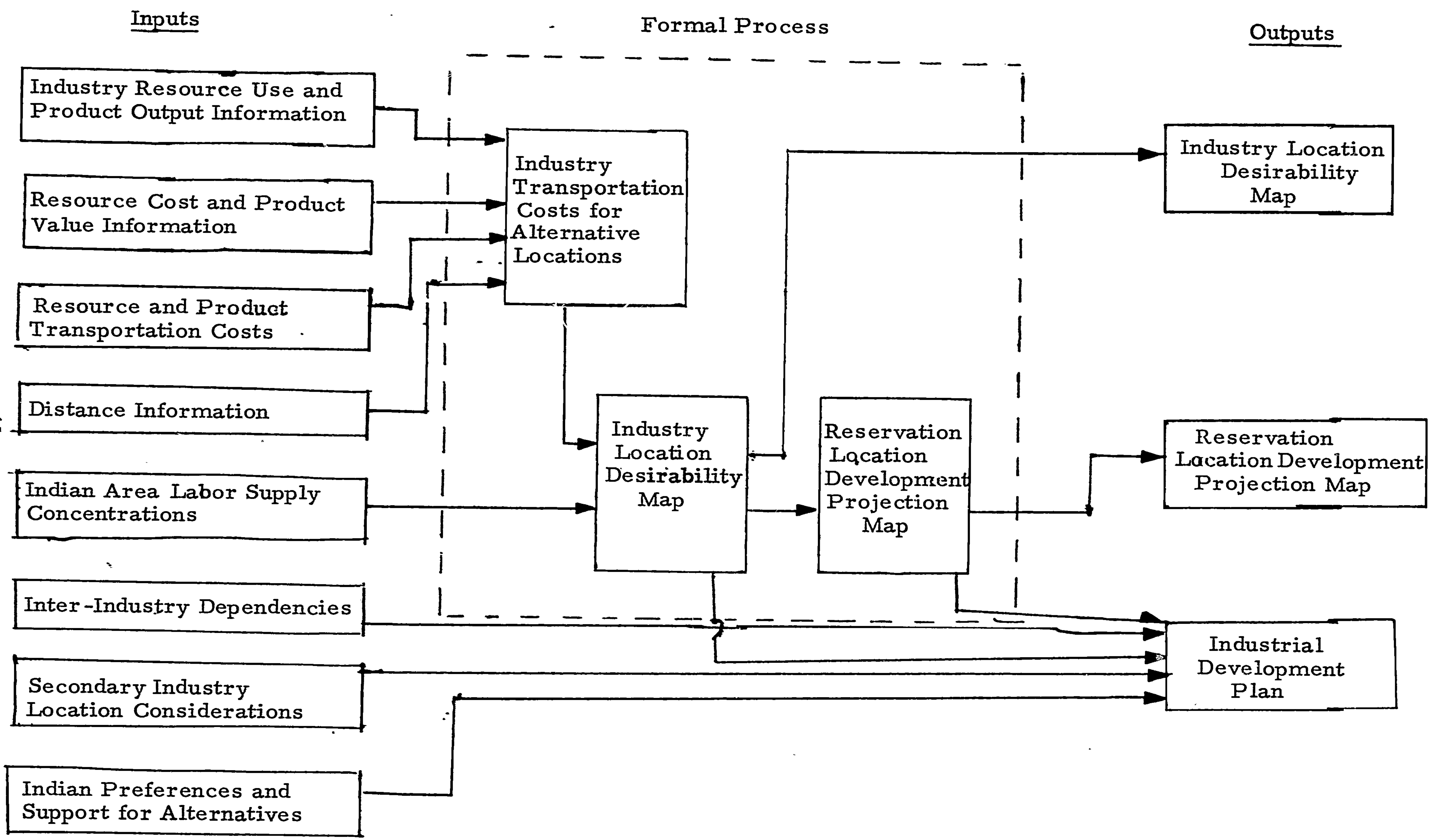



YEARLY TRANSPORTATION COSTS FOR LOCATIONS
ON THE FORT APACHE RESERVATION

(x $1000)

I. Within 10 miles of town > 500
II. Within 10 miles of town > 1000
III. Within 10 miles of town > 2000

BIA ECONOMIC PROJECTION MODEL



Indian Area to attract industry types, or, if certain industries are known to be considering location in the area, to plan school facilities on that basis. If, for example, negotiations were in progress with a company, the location map for that industry, as well as the more general Location Development Projection Map, could be used as a basis for planning facilities.

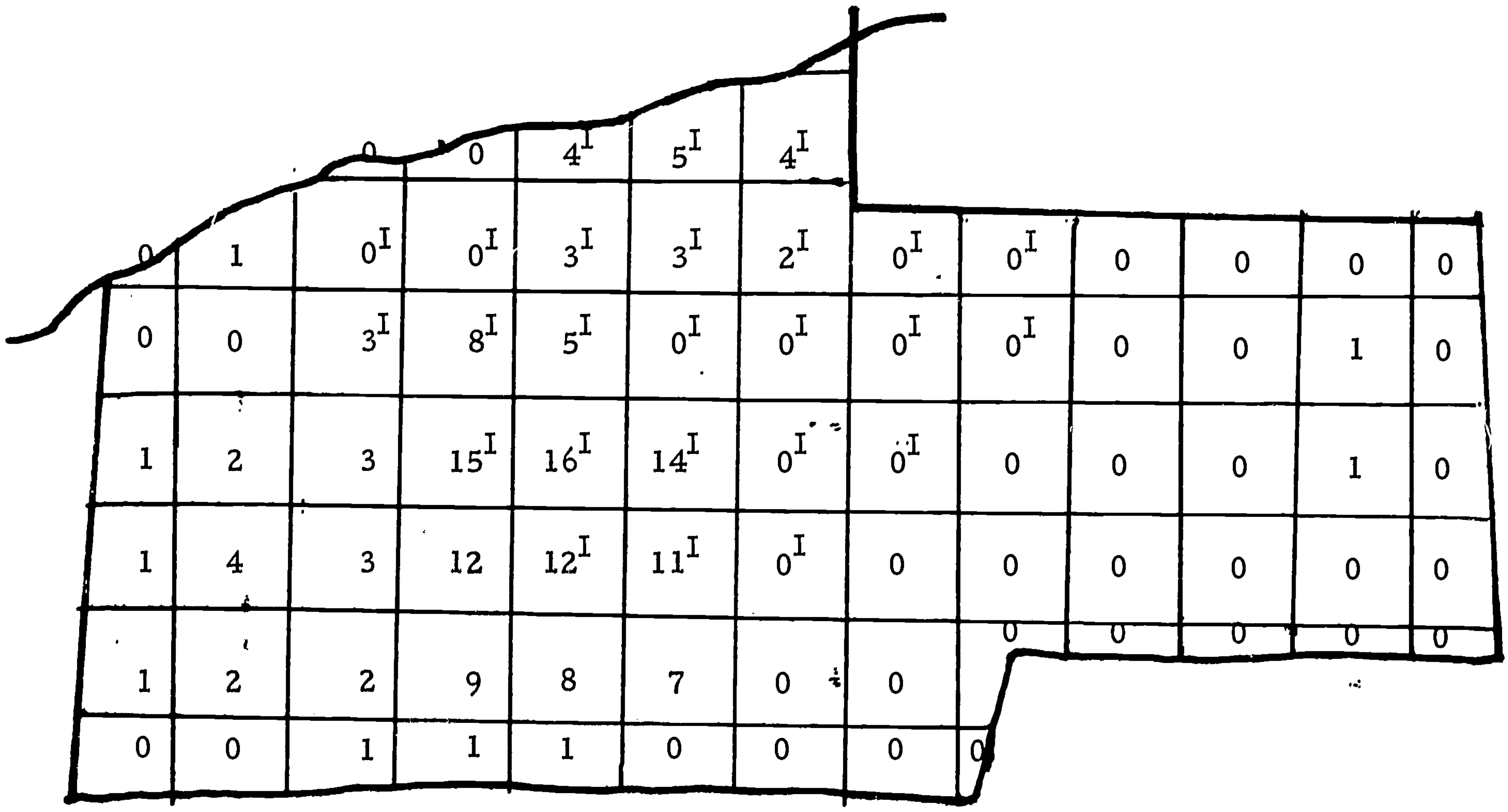
The Location Development Projection Map (see chart on following page) describes each grid square in the area, in terms of the number of industry types for which that location constitutes a savings in transportation costs over all other companies in the industry. Also present on the map is a designation of proximity to towns of various sizes. A list following the map supplies the industry types for which transportation savings are to be gained by location in the Indian Area. In parentheses appears the number of grid square locations at which such savings can be made. This set of outputs provides general information about the relative value of various locations for economic development, and can be used as the basis of decisions on the location of school facilities when more specific information is not available. The intersection of population concentrations and of locations for which there are savings in transportation costs for a large number of industry types, indicates the areas with the highest probability of industrial development and of a consequent increase in population ocncentration. The development potential of locations where either transportation savings are to be gained, or a concentration of population exists, is less. Of still less development potential are locations where there are neither concentrations of population, nor transportation savings to be gained.

Though it is not the purpose of this model to specify the process of outputs of an industrial development plan, it must be recognized that the information contained in such a plan would be of primary importance in deciding on location of schools, to the degree that an expanding Indian population would concentrate in areas of industrialization. Industry, schools and services cannot be planned independently of one another, if the benefits of each are to be maximized. All decisions regarding economic development must therefore be made available to BIA educational

BIA ECONOMIC PROJECTION MODEL

SAMPLE OUTPUT

Reservation Location Development Projection Map




Number of Industries with Below Average Transportation Costs for Locations on the Fort Apache Reservation

| | | |
|---|---|---|
| I. | - Within 10 miles of town | 500 |
| II. | - Within 10 miles of town | 1000 |
| III. | - Within 10 miles of town | 2000 |

Types of Industry with Below Average Transportation Costs

Drugs, Cleaning and Toilet Preparations (18)
Electronic Components and Accessories (20)
Stone and Clay Products (4)
Forestry and Fishing Products (5)
Crude Petroleum and Natural Gas (3)
Amusements (17)

facility location planners, who must be consulted by economic planners when questions of industrial location are under consideration. In short, both the formal output of the Economic Location Model, and the development plans generated from the formal output and other sources, are essential inputs to the School Facilities Location Model. Uses of both these outputs are discussed in the section (4.2.4) on the School Facilities Location Model.

INPUTS

The Economic Location Model requires considerable data about each of 81 industry types, including the amount spent on inputs to the industry: raw and processed resources and labor, the total value of the industry's output, and the mean cost per unit of the industry's output. In addition, it is necessary to know the mean cost of transporting both inputs and outputs a given unit of distance. Finally, specific information is required about the location of raw materials on the reservation, and the location of transportation nodes on and off the reservation. Some of this information is easily obtainable, while other data will require substantial research, if a fine degree of accuracy is desired in the results of the model.

Even with only limited research, reasonable accuracy of output, on the basis of rough estimates of variables, is quite feasible. This degree of accuracy should be perfectly adequate for both school location and economic development purposes, since differences in costs at alternative locations are likely to be substantial. Moreover, the information provided will be significantly more accurate than any presently available.

Each of the input requirements, possible sources of information, and necessary pre-program manipulations of data is discussed below.

1. $VALUE_{I,J}$ - This matrix is defined as the "mean amount spent for input J or value added in producing output J in industry I. The industrial classification recommended for use is that developed by Leontief[1] in his

[1]Leontief, Wassily, "The Structure of the U.S. Economy," Scientific American, Vol. 212, No.4 (April, 1965) pp. 25-35.

research on input/output economics, since each industry can be treated as producing one general type of output which may be considered as input to other industries. Use of Leontief's classification has as its principle benefit the ready availability of data concerning the value of inputs and outputs for each industry. In some cases (for example, "electricity, gas and water"), a finer breakdown that that used by Leontief would be desirable, since costs of the various resources (power being treated as an input) are likely to vary widely within an area. In addition, though each industry type should represent at least one resource, it is not necessary to include all Leontief industry types as types being considered for location in the Indian Area. Thus, the maximum range of subscript I is 81, while the maximum number of resources J is limited only by the number of resource types for which value used by each industry can be determined; this number would probably not exceed 100, though 81 such values can easily be determined using Leontief's data.

The basic source for the VALUE matrix is the dollar-flow table included in Leontief's article (see following page).[2] Each cell in a column gives the dollar value of input to the industry sector used at the top of the column. The total value of output equals the value added plus the value of each input plus the value of non-competitive imports. As was mentioned earlier, a finer breakdown of value of input may be desired for some resources, in which case additional data to that provided by Leontief may be used.[3] In general the Leontief breakdown of industries

[2] Ibid, pp. 8-9.

[3] Sources of such data include the following:

U.S. Bureau of Labor Statistics, Division of Interindustry Economics, Interindustry Flows of Goods and Services by Industry of Origin and Destination, Section 6, October 1952.

U.S. Department of Commerce, Interindustry Structure of the United States," Table I, Survey of Current Business, November 1964, p. 21.

U.S. Department of Commerce, National Economics Division staff, "Transactions Table, Survey of Current Business, September, 1965. 45:9:33-49, 56.

U.S. Department of Commerce, Bureau of the Census, Biennial Census of Manufacturers (water use)

U.S. Department of Commerce, Bureau of the Census, "Manufacturers' Shipments, Inventories and Orders: 1947-1963." Series M3-1.

U.S. Department of Commerce, Bureau of the Census, "Raw Materials in the U.S. Economy," Working paper #6.

| Group | Row | 1 Footwear and other leather products | 2 Miscellaneous furniture and fixtures | 3 Household furniture | 4 Tobacco manufactures | 5 Apparel | 6 Miscellaneous fabricated textile products | 7 Drugs, cleaning and toilet preparations | 8 Food and kindred products | 9 Special industry machinery and equipment | 10 Ordnance and accessories | 11 Aircraft and parts | 12 Miscellaneous transportation equipment | 13 Radio, television and communication equipment | 14 Materials handling machinery and equipment | 15 Miscellaneous manufacturing | 16 Optical, ophthalmic and photographic equipment | 17 Service industry machines | 18 Household appliances | 19 Scientific and controlling instruments | 20 Office, computing and accounting machines | 21 Farm machinery and equipment | 22 Engines and turbines | 23 Construction, mining and oil field machinery | 24 Miscellaneous electrical machinery, equipment and supplies | 25 Metalworking machinery and equipment | 26 Motor vehicles and equipment | 27 General industrial machinery and equipment | 28 Electric lighting and wiring equipment | 29 Electric industrial equipment and apparatus | 30 Electronic components and accessories | 31 Heating, plumbing and structural metal products | 32 Machine shop products | 33 Metal containers | 34 Stampings, screw machine products and bolts | 35 Other fabricated metal products | 36 Primary nonferrous metal manufacturing | 37 Nonferrous metal ores mining | 38 Primary iron and steel manufacturing | 39 Iron and ferroalloy ores mining | 40 Stone and clay products | 41 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FINAL NONMETAL | | | | | | | | FINAL METAL | | | | | | | | | | | | | | | | | | | | | | BASIC METAL | | | | | | | | | BASIC | |
| FINAL NONMETAL | FOOTWEAR AND OTHER LEATHER PRODUCTS 1 | 346 | | 1 | | 15 | 8 | | | | | | | | | 44 | 1 | | 6 | 4 | | | | | | | | | | | | | 3 | | 1 | 1 | | | | | | |
| | MISCELLANEOUS FURNITURE AND FIXTURES 2 | | 40 | 13 | | | 8 | | | | | 29 | 21 | | 1 | 7 | | 2 | 1 | 17 | 1 | 2 | | | | | 6 | 1 | | | | 17 | | | 1 | 9 | | | | | | |
| | HOUSEHOLD FURNITURE 3 | 1 | 57 | 65 | | | 9 | | | | | | 34 | 180 | | 2 | | 3 | 1 | 3 | | | | 1 | | | 2 | 2 | | | 19 | 11 | | | 1 | 11 | | | | | | |
| | TOBACCO MANUFACTURES 4 | | | | 1510 | | | | 1 | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | APPAREL 5 | 23 | 2 | 2 | | 3271 | 27 | 3 | 52 | 3 | 4 | 15 | 5 | 8 | 1 | 12 | 2 | 2 | 3 | 13 | 3 | 2 | 2 | 3 | 2 | 5 | 14 | 5 | 3 | 6 | 5 | 10 | 3 | | 5 | 9 | 7 | | 20 | | | |
| | MISCELLANEOUS FABRICATED TEXTILE PRODUCTS 6 | 2 | 2 | 6 | | 230 | 180 | 4 | 133 | | | | 2 | | | 9 | | | | 2 | | | | | | | 203 | | | | | 3 | | | 1 | | 1 | | 3 | | 5 | |
| | DRUGS, CLEANING AND TOILET PREPARATIONS 7 | 1 | | | 10 | 2 | 2 | 533 | 282 | 2 | 4 | 7 | 3 | 3 | 1 | 20 | | 2 | 1 | 9 | 1 | 2 | 1 | 2 | | 2 | 25 | 2 | 1 | 1 | | 3 | 1 | 7 | 3 | 3 | 13 | | 47 | | 62 | |
| | FOOD AND KINDRED PRODUCTS 8 | 1 | | 37 | 47 | | | 200 | 14028 | 1 | | | | | | 10 | | | | 16 | | | | | | | | | | | | | | | | | 1 | | 9 | | 8 | |
| FINAL METAL | SPECIAL INDUSTRY MACHINERY AND EQUIPMENT 9 | | 1 | 13 | | | | 12 | | 168 | 7 | 7 | 1 | 3 | 6 | 3 | 3 | 8 | | 8 | 16 | 10 | 3 | 8 | | 41 | 6 | 34 | | 6 | 1 | 39 | 13 | | 3 | 22 | 3 | | 53 | | 8 | |
| | ORDNANCE AND ACCESSORIES 10 | | | | | | | | | 3 | 111 | 879 | | 196 | | 1 | 3 | | | 136 | 3 | 9 | | 1 | | 1 | 8 | 1 | | 9 | 29 | 1 | | | 3 | 2 | 2 | | 2 | | | |
| | AIRCRAFT AND PARTS 11 | | 2 | | | | 1 | | | 12 | 1288 | 3230 | 23 | 69 | 3 | 6 | | 19 | 1 | 76 | 20 | 7 | 30 | 3 | 2 | 27 | 12 | 84 | | 8 | | 16 | 7 | 9 | 8 | 7 | | | 2 | | 1 | |
| | MISCELLANEOUS TRANSPORTATION EQUIPMENT 12 | | 1 | | | | | | | 11 | 22 | 4 | 337 | 1 | 6 | 15 | 1 | 1 | 9 | 7 | | 7 | 27 | 20 | | 1 | 27 | 25 | | 35 | | 76 | 7 | | 1 | 7 | 8 | | 21 | 1 | | |
| | RADIO, TELEVISION AND COMMUNICATION EQUIPMENT 13 | | 3 | 1 | | | | | | 33 | 215 | 460 | 8 | 406 | | 18 | 9 | 9 | 1 | 50 | 28 | | | 3 | 9 | | 150 | 9 | 7 | 69 | 120 | 1 | 1 | | 1 | 3 | 11 | | | 2 | | |
| | MATERIALS HANDLING MACHINERY AND EQUIPMENT 14 | | | 3 | | | | | | 16 | | 7 | 21 | | 55 | | | 3 | | | | 1 | 4 | 23 | | 12 | 7 | 38 | | 3 | | 11 | 1 | | 1 | 9 | 1 | | 3 | | | 30 |
| | MISCELLANEOUS MANUFACTURING 15 | 16 | 31 | 21 | 9 | 348 | 51 | 7 | 40 | 3 | 18 | 30 | 12 | 14 | 40 | 200 | 4 | 5 | 6 | 26 | 4 | 3 | 4 | 2 | 1 | 12 | 26 | 1 | 16 | 3 | 6 | 10 | 1 | 2 | 25 | 27 | 18 | | 16 | | 25 | 1 |
| | OPTICAL, OPHTHALMIC AND PHOTOGRAPHIC EQUIPMENT 16 | 4 | | | | | | | | 7 | 4 | 35 | 1 | 18 | | | 113 | | 7 | 26 | | | | | 1 | 1 | 1 | 1 | | 5 | 1 | 2 | | | 3 | 1 | 1 | | 2 | | 1 | |
| | SERVICE INDUSTRY MACHINES 17 | | 19 | | | | | 2 | | 16 | 25 | 11 | 12 | 5 | 3 | 2 | | 140 | 140 | 8 | | | | 3 | | 9 | 39 | 43 | 3 | 2 | | 89 | 1 | | 9 | 11 | 3 | | 2 | | 1 | |
| | HOUSEHOLD APPLIANCES 18 | | 1 | 5 | | | | 1 | | 4 | 1 | 38 | 25 | 3 | | 15 | | 180 | 52 | 4 | | 12 | | 1 | 5 | 9 | | | 1 | 4 | 3 | 73 | | 7 | 12 | 17 | 5 | | 3 | | | |
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| | OFFICE COMPUTING AND ACCOUNTING MACHINES 20 | | 4 | | | | | | | 5 | 5 | 8 | | 9 | 2 | 19 | 1 | | | 82 | 256 | | | 1 | 1 | | | | | 4 | 17 | 3 | 1 | | 3 | 1 | | | 2 | | | |
| | FARM MACHINERY AND EQUIPMENT 21 | | 1 | | | | | | | 9 | 7 | 3 | 28 | | 7 | 2 | | 1 | | 2 | | 126 | 40 | 73 | 1 | 8 | 32 | 11 | 1 | 1 | | 19 | 1 | | 5 | 9 | | | 36 | | | |
| | ENGINES AND TURBINES 22 | | | | | | | | | 2 | 7 | 26 | 182 | | 21 | | | 5 | | | | 183 | 272 | 108 | 2 | 9 | 115 | 65 | | 108 | | 43 | 11 | | 7 | 9 | | 1 | 3 | 1 | | |
| | CONSTRUCTION, MINING AND OIL FIELD MACHINERY 23 | | 1 | | | | | | | 26 | 3 | 3 | 27 | 1 | 73 | | 1 | 2 | 2 | 3 | | 43 | 82 | 233 | 3 | 8 | 13 | 37 | 1 | 8 | 3 | 32 | 7 | | 1 | 25 | | 18 | 19 | 32 | 1 | 191 |
| | MISCELLANEOUS ELECTRICAL MACHINERY EQUIPMENT AND SUPPLIES 24 | | | | | | | | 5 | 1 | 2 | 61 | 6 | 3 | 3 | 1 | 7 | | 1 | 4 | 1 | 26 | 52 | 6 | 78 | | 408 | 5 | 89 | 15 | 3 | 1 | 4 | | 1 | 3 | 66 | | | | | |
| | METALWORKING MACHINERY AND EQUIPMENT 25 | | 5 | 4 | | | 1 | 1 | 16 | 76 | 70 | 330 | 26 | 37 | 24 | 6 | 9 | 9 | 38 | 57 | 27 | 60 | 50 | 71 | 29 | 277 | 342 | 89 | 17 | 79 | 20 | 59 | 38 | 34 | 56 | 227 | 96 | 1 | 171 | | 12 | |
| | MOTOR VEHICLES AND EQUIPMENT 26 | | 5 | | | | | | | 9 | 27 | 109 | 67 | 1 | 14 | 6 | | 37 | 10 | 68 | | 55 | 76 | 61 | 70 | 231 | 1030 | 31 | | 11 | | 43 | 9 | | 130 | 42 | 19 | 1 | 48 | 1 | 2 | 8 |
| | GENERAL INDUSTRIAL MACHINERY AND EQUIPMENT 27 | 1 | 3 | 1 | | | 2 | | 2 | 186 | 40 | 184 | 77 | 11 | 99 | 7 | | 46 | 52 | 27 | 19 | 180 | 95 | 238 | 34 | 158 | 173 | 344 | 5 | 60 | 4 | 124 | 20 | 19 | 3 | 71 | 42 | 3 | 80 | | 4 | 7 |
| | ELECTRIC LIGHTING AND WIRING EQUIPMENT 28 | 3 | 2 | 4 | 1 | | | | 30 | 2 | 74 | 22 | 17 | 92 | 4 | 21 | 8 | 19 | 38 | 16 | 12 | 2 | 1 | 5 | 78 | 3 | 127 | 5 | 123 | 115 | 26 | 22 | 2 | 1 | 20 | 20 | 74 | 1 | 13 | 1 | 38 | |
| | ELECTRIC INDUSTRIAL EQUIPMENT AND APPARATUS 29 | | 1 | 1 | | | | | 11 | 130 | 137 | 57 | 187 | 134 | 71 | 41 | 27 | 284 | 201 | 161 | 69 | 21 | 51 | 47 | 48 | 153 | 68 | 298 | 105 | 455 | 118 | 122 | 10 | 3 | 21 | 33 | 47 | 6 | 112 | 1 | 9 | 4 |
| | ELECTRONIC COMPONENTS AND ACCESSORIES 30 | 3 | | 1 | | | | | | 9 | 5 | 102 | 1 | 1456 | 1 | 14 | | | | 136 | 123 | | | 1 | 28 | | 24 | 2 | 11 | 187 | 218 | 11 | | | 5 | 7 | 3 | | | | 2 | |
| BASIC METAL | HEATING, PLUMBING AND STRUCTURAL METAL PRODUCTS 31 | 1 | 26 | 14 | | | | | | 37 | 12 | 10 | 229 | 5 | 18 | 3 | | 99 | 76 | 6 | | 8 | 4 | 68 | | 18 | 31 | 92 | 7 | 19 | 2 | 201 | 4 | 13 | 39 | 76 | 4 | 1 | 64 | 2 | 7 | |
| | MACHINE SHOP PRODUCTS 32 | | | 1 | | | | | 1 | 14 | 496 | 168 | 18 | 8 | 23 | 16 | 1 | 3 | 5 | 35 | 7 | 50 | 88 | 19 | 17 | 30 | 186 | 26 | 5 | 12 | 4 | 44 | 142 | 13 | 16 | 29 | 45 | | 192 | | 5 | 1 |
| | METAL CONTAINERS 33 | | | | 10 | | | 144 | 2023 | | | | | | | | | | | 11 | | | | | | 1 | | | | | | | | 4 | 17 | 6 | | | | | | |
| | STAMPINGS, SCREW MACHINE PRODUCTS AND BOLTS 34 | 2 | 15 | 23 | 1 | | 1 | 29 | 232 | 42 | 41 | 328 | 25 | 150 | 26 | 96 | 12 | 105 | 298 | 84 | 33 | 109 | 68 | 43 | 50 | 130 | 842 | 55 | 84 | 102 | 63 | 308 | 11 | 37 | 133 | 171 | 125 | 1 | 167 | | 15 | |
| | OTHER FABRICATED METAL PRODUCTS 35 | 32 | 73 | 385 | 12 | 23 | 8 | 77 | 113 | 56 | 64 | 178 | 106 | 96 | 31 | 123 | 21 | 79 | 180 | 77 | 18 | 23 | 8 | 54 | 9 | 180 | 1883 | 98 | 54 | 57 | 48 | 334 | 44 | 11 | 130 | 388 | 143 | 2 | 447 | 1 | 121 | 1 |
| | PRIMARY NONFERROUS METAL MANUFACTURING 36 | 2 | 27 | 37 | 9 | | | 1 | 47 | 151 | 302 | 481 | 92 | 187 | 17 | 398 | 56 | 161 | 208 | 187 | 56 | 26 | 97 | 30 | 218 | 143 | 347 | 142 | 188 | 402 | 188 | 785 | 163 | 27 | [illegible] | 888 | 3069 | 9 | 425 | 2 | 20 | 2 |
| | NONFERROUS METAL ORES MINING 37 | | | | | | | 1 | | | | | | | | | | | | 2 | | | | | 2 | | | | 5 | | | | | | | 2 | 1068 | 308 | 9 | 53 | 5 | 1 |
| | PRIMARY IRON AND STEEL MANUFACTURING 38 | | 187 | 105 | | 1 | 1 | 1 | 2 | 301 | 83 | 842 | 503 | 75 | 188 | 184 | 12 | 266 | 378 | 90 | 68 | 608 | 382 | 641 | 59 | 371 | 2864 | 534 | 307 | 304 | 72 | 2570 | 188 | 1218 | 953 | 1888 | 158 | 68 | 5305 | 28 | 41 | 30 |
| | IRON AND FERROALLOY ORES MINING 39 | | | | | | | | | | | | | | | | | | | | | | | | 3 | 1 | | | | 4 | | | | | | | 29 | 17 | 1306 | 84 | 12 | 1 |
| BASIC NONMETAL | STONE AND CLAY PRODUCTS 40 | 10 | 4 | 11 | | | | 18 | 4 | 15 | 17 | 64 | 41 | 25 | 6 | 17 | 39 | 18 | 38 | 17 | 8 | 19 | 19 | 24 | 19 | 36 | 85 | 46 | 21 | 53 | 25 | 67 | 37 | 6 | 38 | 61 | 63 | 8 | 396 | 1 | 1222 | 136 |
| | STONE AND CLAY MINING AND QUARRYING 41 | | | | | | | 5 | 5 | | | | | | | 1 | | | | | | 1 | | 1 | | | | 12 | | | | 2 | | | | 1 | 6 | | 73 | | 882 | 18 |
| | PRINTING AND PUBLISHING 42 | 23 | 2 | 2 | 17 | 18 | 4 | 36 | 183 | 3 | 13 | 14 | 3 | 12 | 1 | 38 | 1 | 1 | 3 | 3 | 10 | 2 | 4 | 2 | | | 16 | 3 | 1 | 8 | 2 | 6 | | 8 | 7 | 22 | 12 | 1 | 38 | | 21 | 1 |
| | GLASS AND GLASS PRODUCTS 43 | | 75 | 82 | | | | 177 | 804 | | 8 | 2 | 26 | 37 | | 37 | 23 | 8 | 9 | 15 | 1 | | 2 | | 1 | 1 | 312 | | 89 | 8 | 313 | 40 | | | 5 | 2 | | | 2 | | 8 | |
| | PAPERBOARD CONTAINERS AND BOXES 44 | 51 | 37 | 81 | 94 | 118 | 29 | 388 | 1170 | 1 | 21 | 13 | 2 | 42 | 1 | 272 | 14 | 25 | 47 | 37 | 5 | 7 | 14 | 4 | 14 | 1 | 33 | 8 | 54 | 27 | 20 | 42 | | 37 | 45 | 48 | 9 | | 20 | | 97 | 4 |
| | PAPER AND ALLIED PRODUCTS, EXCEPT CONTAINERS 45 | 36 | 7 | 18 | 83 | 19 | 39 | 77 | 498 | 7 | 9 | 7 | 8 | 36 | 1 | 157 | 67 | 12 | 7 | 23 | 20 | 2 | 3 | 4 | 3 | | 111 | 14 | 9 | 54 | 42 | 20 | | 12 | 22 | 33 | 37 | 1 | 64 | | 221 | 18 |
| | WOODEN CONTAINERS 46 | 1 | | 1 | 12 | | | | 131 | 1 | 6 | | | | | 3 | | 15 | 28 | 1 | 1 | 1 | | | | | | | | | | 11 | | 1 | 2 | 7 | | | 4 | | 15 | |
| | LUMBER AND WOOD PRODUCTS, EXCEPT CONTAINERS 47 | 36 | 120 | 544 | 2 | | | 9 | 5 | 19 | 2 | 29 | 122 | 15 | 1 | 132 | | 10 | 8 | 4 | 2 | 12 | 1 | 5 | | 7 | 17 | 7 | 4 | 9 | 1 | 25 | | 1 | 25 | 70 | 14 | 2 | 26 | 9 | 18 | |
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| | MISCELLANEOUS TEXTILE GOODS AND FLOOR COVERINGS 49 | 55 | 35 | 58 | | 108 | 223 | | 1 | | 1 | 8 | 4 | | | 48 | 1 | | | 3 | | | 1 | | | | 119 | | | 2 | | | | | 1 | 10 | 7 | | 1 | | 2 | |
| | RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS 50 | 245 | 18 | 177 | 13 | 31 | 90 | 84 | 188 | 42 | 181 | 186 | 45 | 79 | 28 | 258 | 15 | 35 | 158 | 58 | 32 | 112 | 15 | 83 | 95 | 19 | 870 | 21 | 47 | 50 | 24 | 15 | 4 | 41 | 32 | 81 | 22 | 5 | 82 | 1 | 104 | |
| | BROAD AND NARROW FABRICS, YARN AND THREAD MILLS 51 | 107 | 4 | 248 | 2 | [illegible] | 1361 | 1 | 10 | 4 | | 3 | 3 | 2 | 2 | 131 | 1 | | 12 | 37 | | | | | 1 | | 87 | 3 | | 2 | | 3 | | | | 7 | 20 | 2 | | | 18 | |
| | PAINTS AND ALLIED PRODUCTS 52 | | 33 | 89 | | | 1 | 18 | 8 | 1 | 3 | 14 | 40 | 4 | 4 | 52 | | 15 | 28 | 3 | 3 | 13 | 4 | 8 | | | 118 | 3 | 15 | 20 | 2 | 29 | | 48 | 24 | 14 | 10 | | 20 | | 12 | |
| | LEATHER TANNING AND INDUSTRIAL LEATHER PRODUCTS 53 | 864 | 3 | 5 | | 50 | | | | 4 | | | 2 | 1 | | 45 | | | 1 | 4 | | 4 | | 1 | | | 9 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | | | | 1 | |
| | LIVESTOCK AND LIVESTOCK PRODUCTS 54 | | | | | | | 7 | 19791 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | MISCELLANEOUS AGRICULTURAL PRODUCTS 55 | | | | 1457 | 11 | | 3 | 6366 | | | | | | | 13 | | | | 6 | | | | | | | | | | | | | | | | | | | | | 5 | |
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| | PLASTICS AND SYNTHETIC MATERIALS 57 | 3 | 2 | 2 | 141 | 186 | | 21 | 19 | 2 | | 12 | 37 | 58 | 1 | 181 | 1 | 3 | 13 | 11 | 4 | 1 | 2 | 2 | 11 | 2 | 35 | 1 | 57 | 47 | 27 | 4 | | 3 | 20 | 8 | 150 | | 6 | | 112 | |
| | CHEMICALS AND SELECTED CHEMICAL PRODUCTS 58 | 1 | | | 7 | 56 | | 1112 | 292 | 7 | 14 | 21 | 11 | 8 | | 59 | 125 | 19 | 25 | 14 | 1 | 3 | | 4 | 44 | 5 | 54 | 9 | 17 | 26 | 41 | 27 | | | 18 | 84 | 139 | 55 | 248 | 17 | 216 | |
| | CHEMICAL AND FERTILIZER MINERAL MINING 59 | | | | | | | | 11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 | 2 | 10 | | 30 | |
| ENERGY | PETROLEUM REFINING AND RELATED INDUSTRIES 60 | 1 | 4 | 9 | 4 | 8 | 3 | 85 | 377 | 19 | 14 | 41 | 22 | 10 | 5 | 22 | 5 | 9 | 6 | 6 | 5 | 13 | 12 | 18 | 3 | 25 | 63 | 19 | 6 | 21 | 6 | 57 | 21 | 9 | 31 | 39 | 56 | 11 | 198 | 14 | 114 | |
| | ELECTRICITY, GAS AND WATER 61 | 14 | 11 | 25 | 8 | 60 | 11 | 36 | 472 | 19 | 24 | 82 | 32 | 22 | 6 | 35 | 8 | 15 | 29 | 19 | 10 | 19 | 13 | 25 | 13 | 30 | 144 | 30 | 18 | 47 | 26 | 67 | 17 | 19 | 44 | 63 | 288 | 39 | 614 | 22 | 284 | |
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| | TRANSPORTATION AND WAREHOUSING 65 | 49 | 35 | 97 | 96 | 138 | 29 | 188 | 3405 | 38 | 87 | 150 | 87 | 92 | 17 | 108 | 29 | 45 | 77 | 45 | 25 | 54 | 37 | 60 | 26 | 38 | 586 | 68 | 41 | 81 | 37 | 191 | 21 | 70 | 75 | 116 | 285 | 20 | 1309 | 32 | 598 | |
| | STATE AND LOCAL GOVERNMENT ENTERPRISES 66 | | | 1 | 1 | 2 | 1 | 2 | 39 | 1 | 1 | 3 | 1 | 1 | | 2 | | 1 | 1 | 1 | | 1 | | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 1 | 2 | | | 1 | 2 | 4 | 1 | 18 | | 13 | |
| | HOTELS, PERSONAL AND REPAIR SERVICES, EXCEPT AUTOMOBILE 67 | 12 | 3 | 9 | 3 | 49 | 5 | 5 | 50 | 5 | 5 | | 8 | 8 | 2 | 13 | 3 | 3 | 5 | 6 | 4 | 4 | 3 | 4 | 3 | 8 | 20 | 6 | 4 | 9 | 7 | 13 | 4 | 2 | 7 | 13 | 10 | 1 | 29 | 1 | 15 | |
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| | MEDICAL AND EDUCATIONAL SERVICES, NONPROFIT ORGANIZATIONS 71 | 5 | 2 | 5 | 8 | 22 | 3 | 8 | 85 | 3 | 6 | 15 | 5 | 8 | 1 | 8 | 2 | 3 | 5 | 5 | 3 | 3 | 3 | 4 | 2 | 8 | 31 | 5 | 3 | 7 | 4 | 11 | 2 | 3 | 5 | 8 | 12 | 1 | 27 | 1 | 11 | |
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| | COMMUNICATIONS, EXCEPT RADIO AND TELEVISION BROADCASTING 74 | 12 | 8 | 23 | 3 | 57 | 7 | 19 | 211 | 33 | 28 | 76 | 14 | 27 | 5 | 39 | 6 | 10 | 20 | 21 | 13 | 9 | 8 | 13 | 7 | 40 | 63 | 45 | 8 | 28 | 10 | 43 | 14 | 3 | 13 | 24 | 37 | 3 | 91 | 2 | 35 | |
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| | BUSINESS TRAVEL, ENTERTAINMENT AND GIFTS 80 | 29 | 21 | 38 | 14 | 127 | 21 | 83 | 459 | 47 | 124 | 70 | 52 | 146 | 19 | 91 | 21 | 31 | 48 | 108 | 70 | 29 | 30 | 44 | 28 | 57 | 129 | 68 | 39 | 143 | 72 | 93 | 23 | 10 | 50 | 94 | 63 | 7 | 113 | 6 | 98 | |
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| | NONCOMPETITIVE IMPORTS | | | 1 | | 11 | | 17 | 1980 | 8 | | | | | | 116 | | | | 1 | | | | | | 17 | | | | 8 | 8 | | | | | | 16 | | | | 15 | |
| | VALUE ADDED | 1822 | 900 | 1821 | 3818 | 7345 | 705 | 3706 | 23948 | 1499 | 2172 | 8018 | 1828 | 3563 | 542 | 2967 | 1106 | 1017 | 1802 | 2202 | 1898 | 1244 | 1255 | 1837 | 871 | 2487 | 9056 | 2182 | 1435 | 3384 | 1760 | 4139 | 1128 | 932 | 2168 | 3733 | 4310 | 827 | 10211 | 578 | 4918 | [illegible] |

ENERGY

SERVICES

...ES
WOODEN CONTAINERS
...O PRODUCTS EXCEPT CONTAINERS
FORESTRY AND FISHERY PRODUCTS
MISCELLANEOUS TEXTILE GOODS AND FLOOR COVERINGS
RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS
BROAD AND NARROW FABRICS, YARN AND THREAD MILLS
LEATHER TANNING AND INDUSTRIAL LEATHER PRODUCTS
PAINTS AND ALLIED PRODUCTS
MISCELLANEOUS AGRICULTURAL PRODUCTS
LIVESTOCK AND LIVESTOCK PRODUCTS
AGRICULTURAL, FORESTRY AND FISHERY SERVICES
PLASTICS AND SYNTHETIC MATERIALS
CHEMICALS AND SELECTED CHEMICAL PRODUCTS
CHEMICAL AND FERTILIZER MINERAL MINING
PETROLEUM REFINING AND RELATED INDUSTRIES
ELECTRIC, GAS AND WATER
CRUDE PETROLEUM AND NATURAL GAS
COAL MINING
FEDERAL GOVERNMENT ENTERPRISES
STATE AND LOCAL GOVERNMENT ENTERPRISES
TRANSPORTATION AND WAREHOUSING
HOTELS, PERSONAL AND REPAIR SERVICES EXCEPT AUTOMOBILE
AUTOMOBILE REPAIR AND SERVICES
RADIO AND TELEVISION BROADCASTING
MEDICAL AND EDUCATIONAL SERVICES, NONPROFIT ORGANIZATIONS
AMUSEMENTS
COMMUNICATIONS EXCEPT RADIO AND TELEVISION BROADCASTING
WHOLESALE AND RETAIL TRADE
FINANCE AND INSURANCE
REAL ESTATE AND RENTAL
BUSINESS SERVICES
MAINTENANCE AND REPAIR CONSTRUCTION
RESEARCH AND DEVELOPMENT
OFFICE SUPPLIES
BUSINESS TRAVEL, ENTERTAINMENT AND GIFTS
SCRAP, USED AND SECONDHAND GOODS
PERSONAL CONSUMPTION EXPENDITURES
INVESTMENT (PRODUCERS' DURABLE EQUIPMENT)
NEW CONSTRUCTION
NET INVENTORY CHANGE
FEDERAL GOVERNMENT PURCHASES
STATE AND LOCAL GOVERNMENT PURCHASES
EXPORTS
COMPETITIVE IMPORTS
TOTAL FINAL DEMAND
GROSS DOMESTIC OUTPUT

| Row | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | | 1 | | 1 | 10 | | | 3 | 1 | 5 | | | | |
| 2 | | 2 | 1 | 4 | | | | | | | | | | | | |
| 3 | | | 4 | 25 | | 8 | 1 | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | |
| 5 | 4 | 9 | | 14 | | 9 | 24 | 22 | 1 | | | | | 3 | 7 | |
| 6 | | 32 | | 2 | | 16 | 4 | 45 | | 2 | 10 | 46 | | | 39 | |
| 7 | 8 | 28 | | 12 | | 1 | 8 | 31 | 27 | 30 | 36 | | | 60 | 884 | |
| 8 | | 182 | | | 33 | 21 | 2 | 11 | 79 | 276 | 3704 | 4 | 10 | 23 | 501 | |
| 9 | 18 | 38 | 2 | 17 | | 2 | 7 | 84 | | | | | | 7 | 154 | |
| 10 | 2 | | | | | | | | | | | | | | | |
| 11 | | | | | | 1 | 23 | | | | | | | | 1 | |
| 12 | | | | 9 | 27 | | 3 | | | | | 4 | | | | |
| 13 | | | | | | | 6 | | | | | | | 1 | | |
| 14 | | | | 5 | | | | | | | | | | | 9 | 4 |
| 15 | 5 | 13 | | 17 | 3 | 25 | 41 | 22 | 2 | 1 | 1 | 1 | 1 | 3 | 24 | |
| 16 | | 4 | | | | | 3 | | | | | | | 13 | 7 | |
| 17 | | 1 | | | | | | | | | | | | | 1 | |
| 18 | | | | | | | 4 | | | | | | | | | |
| 19 | | 4 | | | | | 13 | | | | | | | 1 | 4 | |
| 20 | | 2 | | | | | | | | | | | | | 9 | |
| 21 | | | | | | 1 | | | | | 6 | 296 | | | | |
| 22 | | | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | | | 19 |
| 24 | | | | 1 | | | 1 | | | | 8 | 28 | | | | |
| 25 | 3 | 11 | | 2 | | 1 | 6 | 3 | | 1 | | | | 7 | 11 | |
| 26 | | | | 1 | | 1 | | | | | 30 | 45 | | | | 2 |
| 27 | 2 | 8 | | 14 | | | 9 | 2 | | | | | | 3 | 5 | 1 |
| 28 | 2 | 17 | 1 | 13 | | 1 | 14 | 4 | | 1 | 1 | 1 | | 2 | 2 | |
| 29 | 1 | 6 | | | | | 5 | 1 | | 1 | | | | 4 | 20 | 4 |
| 30 | | | | | | | 3 | | | | | | | | | |
| 31 | | 1 | | 4 | | | 4 | 1 | 1 | | | | | 1 | 3 | |
| 32 | 1 | 5 | | 4 | | | 24 | | | | 2 | 4 | | 2 | 6 | |
| 33 | 19 | 1 | | | | | | | 117 | | 6 | 19 | | 7 | 192 | |
| 34 | 5 | 21 | 1 | 28 | | | 30 | 2 | 1 | 1 | 27 | | | 4 | 13 | 1 |
| 35 | 12 | 143 | 4 | 88 | 1 | 4 | 182 | 12 | 4 | 2 | 36 | 50 | 12 | 8 | 57 | 1 |
| 36 | 1 | 18 | | 13 | | 1 | 17 | 3 | 1 | | 1 | 1 | | 2 | 304 | 2 |
| 37 | | | | | | | | | | | | | | | 75 | |
| 38 | 3 | 1 | 24 | | | 1 | 18 | 5 | 14 | | | | | | 282 | 14 |
| 39 | | | | | | | | | | | | | | | 74 | 1 |
| 40 | | 65 | 1 | 43 | | 3 | 32 | 3 | 25 | 11 | 1 | 33 | | 2 | 49 | |
| 41 | | 47 | | | | | 8 | | 1 | | 1 | 87 | | 1 | 29 | 12 |
| 42 | 33 | 134 | 1 | 42 | | 2 | 29 | 11 | 6 | 2 | 9 | 9 | | 6 | 40 | |
| 43 | 8 | 1 | | 13 | | 3 | 59 | 31 | | | 4 | | | 2 | 24 | |
| 44 | 189 | 388 | 1 | 48 | 13 | 20 | 67 | 113 | 27 | 2 | 17 | 3 | 8 | 31 | 94 | 1 |
| 45 | 8888 | 3888 | 1 | 78 | 11 | 35 | 38 | 22 | 19 | 4 | | | 3 | 297 | 158 | 4 |
| 46 | 3 | 7 | 22 | 27 | | | | | | 3 | | 131 | | 1 | 4 | |
| 47 | 4 | 877 | 281 | 3183 | | | 15 | 2 | 2 | | 2 | 2 | | 1 | 41 | |
| 48 | | | | 1080 | 21 | | | | | 1 | | | | | 20 | |
| 49 | | 22 | | 2 | 15 | 879 | 610 | 338 | | | 7 | 35 | 15 | 1 | 3 | |
| 50 | 43 | 180 | 1 | 71 | 11 | 47 | 279 | 57 | 8 | 11 | 27 | 898 | 2 | 180 | 111 | 4 |
| 51 | | 78 | | | | 561 | 183 | 4004 | 1 | | | 9 | | 5 | 1 | |
| 52 | | 4 | 1 | 50 | 3 | 2 | 2 | 5 | 4 | | | | | 35 | 57 | |
| 53 | | | | | | | 7 | 2 | | 108 | | | | | | |
| 54 | | | | | 89 | 72 | 108 | 138 | | 69 | 5230 | 2823 | 201 | | | |
| 55 | | | | 271 | 217 | 20 | | 1562 | | | 8240 | 883 | 700 | | 18 | |
| 56 | | | | 11 | 23 | | | | | | 616 | 1143 | 2 | | | |
| 57 | 15 | 123 | | 75 | | 833 | 1304 | 1221 | 888 | | | | | 192 | 318 | |
| 58 | 11 | 444 | | 80 | | 10 | 688 | 221 | 874 | 84 | 43 | 1498 | | 1887 | 3128 | 23 |
| 59 | | 21 | | | | | 10 | 1 | | 1 | | 37 | | 1 | 467 | 43 |
| 60 | 33 | 108 | 4 | 101 | 25 | 8 | 22 | 35 | 23 | 5 | 60 | 1171 | 3 | 74 | 876 | 7 |
| 61 | 24 | 381 | 5 | 73 | 1 | 22 | 94 | 156 | 11 | 9 | 116 | 225 | 2 | 54 | 383 | 32 |
| 62 | 1 | 66 | | 2 | | 2 | 13 | 21 | 1 | 3 | 7 | 1 | | 31 | 81 | 1 |
| 63 | | | | | | | | | | | | | | | 32 | 2 |
| 64 | 4 | 15 | 1 | 4 | 1 | 4 | 8 | 11 | 8 | 8 | 5 | 4 | 1 | 26 | 36 | 1 |
| 65 | 190 | 488 | 21 | 812 | 8 | 64 | 187 | 800 | 73 | 27 | 646 | 381 | 14 | 178 | 481 | 21 |
| 66 | 1 | 17 | | 7 | | 1 | 3 | 3 | 1 | | 1 | 1 | | 2 | 8 | |
| 67 | 8 | 13 | 2 | 21 | | 4 | 12 | 23 | 1 | 2 | | | | 4 | 10 | 1 |
| 68 | 4 | 10 | 5 | 87 | | 2 | 3 | 8 | 4 | 1 | 75 | 66 | | 2 | 21 | |
| 69 | | | | | | | | | | | | | | | | |
| 70 | | | | | | | | 1 | | | | | | | | |
| 71 | 5 | 13 | 1 | 11 | 1 | 3 | 9 | 15 | 3 | 1 | 177 | 18 | 1 | 5 | 14 | 1 |
| 72 | 178 | 880 | 29 | 480 | 24 | 128 | 311 | 488 | 104 | 31 | 1130 | 1290 | 6 | 118 | 444 | 17 |
| 73 | 31 | 93 | 4 | 71 | 39 | 22 | 52 | 94 | 19 | 7 | 238 | 373 | 7 | 39 | 147 | 5 |
| 74 | 11 | 40 | 1 | 28 | 4 | 8 | 28 | 23 | 10 | 4 | 58 | 93 | 8 | 15 | 71 | 1 |
| 75 | 23 | 179 | 3 | 63 | 138 | 24 | 217 | 132 | 37 | 5 | 58 | 1480 | 6 | 71 | 210 | 5 |
| 76 | 46 | 57 | 6 | 73 | 52 | 23 | 88 | 65 | 30 | 4 | 366 | 2380 | 21 | 33 | 181 | 8 |
| 77 | 17 | 55 | | 21 | | 1 | 9 | 9 | 1 | | 290 | 480 | 3 | 35 | 9 | |
| 78 | | 3 | | | | | | 3 | | | | | | 16 | 33 | |
| 79 | 3 | 6 | | 4 | 1 | 1 | 7 | 7 | 2 | | 1 | 3 | | 1 | 14 | |
| 80 | 32 | 77 | 5 | 81 | 2 | 14 | 79 | 57 | 31 | 4 | 22 | 35 | 2 | 11 | 283 | 7 |
| 81 | | 225 | | 4 | | 41 | 4 | | | | | | | 1 | 4 | 1 |
| | | | | 1 | | 55 | 313 | 112 | 11 | 5 | 16 | 313 | | | 54 | |
| | 1807 | 4852 | 218 | 3624 | 750 | 916 | 3975 | 3681 | 911 | 382 | 11294 | 15523 | 900 | 2243 | 6216 | 387 |
| | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 |

| Row | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | 1 | 1 | | 9 | | | 13 | 3 | 24 | 1 | | 1 | 6 | | | | 34 | 1 |
| 2 | | | | | | | | 5 | | | | | 17 | | | | 2 | 22 | | | | |
| 3 | | | | | | | | 15 | | | | | 17 | | | | 4 | | | | | |
| 4 | | | | | | | | | | | | | 4 | | | | 3 | | | | 109 | 2 |
| 5 | 4 | | | | | 6 | 2 | 192 | 2 | | | 51 | 69 | | | 9 | 34 | | 2 | | 9 | 8 |
| 6 | 2 | | | | 3 | 20 | | 179 | 24 | 3 | 7 | 49 | 52 | 41 | 7 | 29 | 4 | 1 | 3 | | | 2 |
| 7 | 64 | 1 | | 1 | | 15 | 4 | 286 | 12 | | 1 | 301 | 186 | 15 | 1 | 37 | 36 | | 31 | | 42 | |
| 8 | 15 | 1 | | | 249 | 182 | 1 | 18 | | | | 286 | 768 | | | | 64 | | 5 | | 2610 | 1 |
| 9 | | | | 12 | | | | 1 | | | | | 37 | | | | 14 | | 5 | | | 27 |
| 10 | | | | | | | | | | | | | 12 | | | | 5 | | 1413 | | 6 | |
| 11 | | | | | | 218 | | | | | | | 90 | | | | 18 | | 2066 | | | 24 |
| 12 | | 2 | 15 | | | 300 | | 12 | 13 | | 1 | 29 | 17 | 13 | 7 | 24 | 8 | | | | | 4 |
| 13 | 8 | 5 | | | | 23 | | 13 | | 47 | | 15 | 85 | | 108 | | 15 | 29 | 486 | | 49 | 79 |
| 14 | | | 15 | | | 18 | | | | | | | 18 | | | | 6 | 11 | 4 | | | 3 |
| 15 | 8 | 8 | 5 | 1 | | 83 | 1 | 344 | 2 | 12 | 116 | 43 | 167 | 30 | 13 | 389 | 19 | 65 | 14 | 270 | 56 | 23 |
| 16 | | | | | | | | 901 | | | 33 | 99 | 48 | | | 256 | 6 | | 42 | 14 | 16 | 1 |
| 17 | | | | | | 3 | | 53 | | | | | 47 | | | 114 | 17 | 29 | 14 | | | 8 |
| 18 | | | | | | | | 157 | | | | | 32 | | | | 14 | 80 | 200 | | 33 | |
| 19 | 2 | | | 1 | | 34 | | 93 | 21 | | | 348 | 56 | | | | 11 | 21 | 145 | | 10 | 36 |
| 20 | | 11 | | | | 3 | | | | | | 4 | 58 | 6 | | 689 | 10 | | 16 | 8 | | 12 |
| 21 | | | | | | | | | | | | | 24 | | | 181 | 6 | | 16 | | | 8 |
| 22 | | 3 | | 20 | | 187 | | | | | | | 15 | | | 186 | 4 | 1 | 65 | | | 3 |
| 23 | | | 1186 | 52 | | | | | | | | | 37 | | | 24 | 10 | 28 | 5 | | | 9 |
| 24 | | 1 | | 2 | 1 | 80 | 1 | 5 | 136 | | | 18 | 85 | 3 | 8 | 6 | 5 | 7 | 31 | | | 0 |
| 25 | 3 | 3 | 13 | | | 31 | | | 1 | | | | 20 | | | 25 | 46 | | 137 | | | 8 |
| 26 | | 1 | 8 | 12 | 12 | 118 | 18 | | 1400 | | | 2 | 276 | | | 7 | 24 | | 246 | | | 117 |
| 27 | 2 | | 5 | 186 | | 19 | | | | | | | 39 | | | | 12 | 25 | 4 | | | 15 |
| 28 | 1 | 3 | 8 | 1 | | 0 | | 10 | 44 | | | | 24 | | | | 4 | 186 | 88 | | | |
| 29 | 4 | 13 | 8 | 44 | | 41 | | 9 | 8 | | | | 31 | | 1 | | 9 | 188 | 226 | | | 7 |
| 30 | | | | 15 | | 33 | | 310 | | | | | 13 | | 7 | | 18 | | 188 | | | |
| 31 | 3 | | 1 | 8 | | 1 | | | | | | | 129 | | | | 12 | 1179 | 20 | | | 29 |
| 32 | 1 | | 1 | 1 | 1 | 8 | 1 | | 180 | | | | 30 | | | 1 | 11 | 1 | 3 | | | 31 |
| 33 | 100 | | | | | | | | | | | | 10 | | | | 3 | | 1 | | | 9 |
| 34 | 3 | | 21 | 7 | | 20 | | | | | | 27 | 56 | | | | 7 | 29 | 4 | | | 44 |
| 35 | 251 | 211 | 19 | 67 | 4 | 54 | 29 | 37 | 130 | | | 1 | 83 | | 4 | 1 | 8 | 70 | 24 | 9 | 5 | 23 |
| 36 | 3 | 11 | 22 | 10 | | 84 | | 8 | | | | | 21 | | 32 | 21 | 15 | 378 | 17 | | | 70 |
| 37 | | 4 | | | | | | | | | | | | | | | 7 | | | | | |
| 38 | 2 | 79 | 30 | 4 | | 50 | 3 | | | | | | 10 | | | | 27 | 265 | 7 | 3 | | 140 |
| 39 | 4 | | | | 2 | | | | | | | | | | | | 7 | | | | | |
| 40 | 46 | 32 | 9 | 5 | 16 | 5 | 1 | 69 | 52 | | | | 130 | | | | 29 | 731 | | | 3 | |
| 41 | 80 | | 2 | | 1 | 2 | | | | | | | 5 | | | | 11 | 179 | | | | |
| 42 | 1 | 7 | 1 | 1 | 50 | 89 | 18 | 8 | 14 | 13 | 27 | 439 | 312 | 582 | 184 | 7890 | 79 | 2 | 1 | 1043 | 8 | 46 |
| 43 | 3 | | | 1 | | 7 | | 4 | 129 | | | 8 | 141 | | | | 8 | 788 | 1 | 1 | 3 | |
| 44 | 43 | 1 | 2 | 1 | 8 | 11 | | 25 | 1 | 3 | 1 | 27 | 467 | 32 | | 11 | 12 | | 2 | | | 24 |
| 45 | 77 | 22 | 9 | 6 | 36 | 44 | 3 | 184 | 4 | 11 | 5 | 113 | 980 | 136 | | 88 | 14 | 91 | 8 | 436 | 4 | |
| 46 | | | | | | 23 | | | | | | | 182 | | | | 3 | | | | | |
| 47 | 3 | 4 | 25 | 8 | | 12 | | 7 | | | | 4 | 77 | | | | 31 | 887 | | | 2 | |
| 48 | | | | | | 2 | | | | | | | | | | | 2 | | | | 20 | |
| 49 | | | | 3 | | 21 | 3 | 31 | 22 | 2 | 4 | 30 | 31 | 29 | 5 | 19 | 8 | 1 | 4 | | | |
| 50 | 8 | 11 | 30 | 41 | 1 | 338 | 7 | 92 | 380 | 1 | 2 | 85 | 314 | 71 | 8 | 87 | 58 | 88 | 39 | 12 | 2 | 8 |
| 51 | | 3 | 2 | | | 9 | | 187 | | | | 3 | 12 | | 1 | | 22 | | 1 | | | 71 |
| 52 | 8 | | 1 | 7 | | 52 | | | 81 | | | | 30 | | | | 14 | 1170 | | | | |
| 53 | | | | | | 4 | | | | | | | 3 | | | | 1 | | | | | |
| 54 | | | | | 2 | 2 | | | | | 15 | 8 | | | | | 1187 | | | | 38 | |
| 55 | | | | | 886 | 45 | | | | | | 7 | | | | | 1000 | | | | 88 | |
| 56 | | | | | | | 1 | | | | 4 | | 288 | | | | 7 | | | | | |
| 57 | 20 | 3 | | | | | | | | | | | 5 | | | | 14 | | 11 | | | |
| 58 | 886 | 13 | 58 | 85 | | 47 | 32 | 131 | | | | 6 | 128 | | | 18 | 198 | 94 | 112 | 13 | | |
| 59 | 2 | | | | | 1 | | | | | | | | | | | 2 | | | | | |
| 60 | 1081 | 480 | 40 | 89 | 8 | 1900 | 54 | 191 | 36 | 3 | 5 | 93 | 983 | 184 | 23 | 166 | 480 | 380 | 29 | | | 8 |
| 61 | 349 | 4501 | 87 | 104 | 97 | 188 | 823 | 313 | 280 | 8 | 57 | 366 | 2541 | 186 | 80 | 387 | 331 | 33 | | | | |
| 62 | 13 | 727 | 680 | | 82 | 35 | 186 | | 14 | | | | 8 | 8 | | 40 | 14 | | | | | |
| 63 | 12801 | 1863 | | 289 | | | 27 | | | | | | | | | | 181 | | 1 | | | |
| 64 | 42 | 283 | 4 | | 8 | 73 | 5 | 8 | 5 | 1 | 4 | 21 | 1300 | 438 | 54 | 876 | 381 | | | | | |
| 65 | 1113 | [illegible] | 27 | 111 | 872 | 2788 | 93 | 130 | 88 | 3 | 30 | 130 | 526 | 212 | 23 | 180 | 516 | 387 | 3 | | 3428 | 58 |
| 66 | 9 | 3400 | 1 | 6 | 1 | 870 | 1 | 25 | 26 | | 2 | 16 | 476 | 93 | 5 | 10 | 884 | 3 | | | | |
| 67 | | | 1 | 1 | | | 10 | 471 | | | | 146 | 200 | | | 108 | 848 | | | | 1247 | |
| 68 | 25 | 33 | 1 | 18 | 47 | 1070 | 8 | 184 | 170 | 2 | | 65 | 1086 | 110 | 21 | 186 | 198 | 30 | | | | |
| 69 | | | | | | | | | | 5 | | | | | | 2963 | 15 | | | | | |
| 70 | | | | | | 33 | | | | 480 | 1708 | 111 | 127 | 7 | 4 | 44 | 130 | | 7 | | 157 | |
| 71 | 22 | 22 | 4 | 12 | | 41 | | 19 | 10 | 2 | 7 | 380 | 127 | 128 | 12 | 5 | 50 | 13 | 718 | | 48 | |
| 72 | 887 | 388 | 127 | 135 | 82 | 1300 | 56 | 880 | 880 | 24 | 94 | 560 | 8096 | 388 | 89 | 881 | 1421 | 1808 | 19 | | 476 | |
| 73 | 186 | 147 | 36 | 143 | 7 | 988 | 60 | 880 | 274 | 17 | 174 | 301 | 8086 | 7143 | 74 | 387 | 2748 | 66 | 7 | | | |
| 74 | 31 | 62 | 3 | 3 | 15 | 387 | 33 | 88 | 73 | 82 | 42 | 253 | 1343 | 540 | 115 | 888 | 288 | 24 | 3 | | | |
| 75 | 460 | 300 | 18 | 485 | 74 | 404 | 91 | 480 | 204 | 83 | 386 | 700 | 6306 | 1300 | 280 | 730 | 1080 | 80 | 27 | | | |
| 76 | 186 | 74 | 81 | 1000 | 54 | 1346 | 95 | 792 | 411 | 184 | 382 | 3080 | 6006 | 2720 | 218 | 1191 | 1087 | 47 | 18 | | | |
| 77 | 34 | 1738 | 3 | 8 | 19 | 1841 | 1904 | 47 | 143 | 11 | 188 | 904 | 1080 | 198 | 416 | 20 | 1607 | 1 | | | | |
| 78 | 8 | | | | 2 | | | | | | | 53 | | | | | | | | | | |
| 79 | 7 | 22 | 1 | 4 | 28 | 57 | 38 | 28 | 4 | 2 | 8 | 116 | 265 | 181 | 51 | 329 | 36 | 3 | | | | |
| 80 | 41 | 80 | 15 | 90 | 48 | 192 | 20 | 202 | 39 | 41 | 115 | 589 | 2122 | 487 | 93 | 285 | 75 | 50 | 22 | | | |
| 81 | 4 | | 7 | 149 | | | | 62 | 88 | | | | 139 | | | | | 16 | | | | |
| | | | | | 245 | 699 | | | | | 140 | 7 | 40 | 142 | 75 | | | | | | | |
| | 4787 | 13201 | 2139 | 8843 | 2378 | 27073 | 3480 | 8857 | 5045 | 1180 | 4005 | 20534 | 81513 | 18859 | 11070 | 14809 | 59513 | 13773 | 547 | | | |
| | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 |

| Row | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3496 | 6 | | 12 | 29 | 4 | 50 | 21 | 3583 | 4133 |
| 2 | 173 | 1080 | 275 | | 34 | 172 | 24 | | 1757 | 2012 |
| 3 | 3106 | 187 | 396 | 8 | 35 | 75 | 22 | | 3664 | 4378 |
| 4 | 5684 | | | 32 | | | 585 | 36 | 6201 | 7816 |
| 5 | 14880 | | | 173 | 56 | 115 | 192 | 45 | 15027 | 18984 |
| 6 | 1482 | | 1 | | 140 | | 25 | 11 | 1635 | 3084 |
| 7 | 4982 | | | 72 | 179 | 243 | 440 | 60 | 5856 | 8829 |
| 8 | 60994 | | 23 | 351 | 262 | 350 | 1499 | 1772 | 61887 | 64718 |
| 9 | 27 | 1861 | | 144 | 41 | 41 | 501 | 44 | 2404 | 3254 |
| 10 | 212 | | 7 | 113 | 3042 | 8 | 25 | 17 | 3388 | 6235 |
| 11 | 34 | 480 | | 360 | 8722 | | 754 | 80 | 9550 | 10078 |
| 12 | 871 | 1301 | 3 | 102 | 880 | 51 | 403 | 80 | 3718 | 4992 |
| 13 | 1821 | 1362 | 48 | 96 | 1861 | 82 | 269 | 56 | 5310 | 8042 |
| 14 | | 479 | 335 | 33 | 185 | 87 | 104 | 20 | 1117 | 1458 |
| 15 | 3380 | 374 | 113 | 45 | 45 | 239 | 157 | 337 | 4025 | 7064 |
| 16 | 810 | 215 | | 6 | 178 | 19 | 118 | 104 | 1043 | 2027 |
| 17 | 325 | 1281 | 263 | 48 | 98 | 27 | 179 | 7 | 2089 | 2874 |
| 18 | 3280 | 127 | 278 | 88 | 29 | | 220 | 2 | 3823 | 4835 |
| 19 | 473 | 722 | 257 | 10 | 746 | 118 | 251 | 155 | 2402 | 4880 |
| 20 | 78 | 1385 | | 18 | 100 | 119 | 182 | 59 | 1746 | 2823 |
| 21 | 10 | 2283 | 3 | 32 | 7 | 25 | 256 | 172 | 2381 | 3303 |
| 22 | 170 | 783 | 3 | 81 | 324 | 3 | 288 | 9 | 1480 | 2942 |
| 23 | | 1781 | 229 | 100 | 109 | 29 | 962 | 1 | 3018 | 4182 |
| 24 | 347 | 113 | 20 | 34 | 121 | 44 | 88 | 29 | 978 | 2039 |
| 25 | 39 | 1582 | 1 | 179 | 233 | 5 | 449 | 51 | 2057 | 4863 |
| 26 | 12282 | 4783 | 2 | 726 | 409 | 599 | 1230 | 863 | 17708 | 30348 |
| 27 | | 1411 | 366 | 111 | 297 | 5 | 368 | 13 | 2282 | 5003 |
| 28 | 420 | 34 | 1087 | 41 | 25 | 13 | 87 | 15 | 1580 | 3082 |
| 29 | 21 | 2156 | 569 | 179 | 241 | 7 | 372 | 77 | 3108 | 6802 |
| 30 | 188 | 30 | 3 | 64 | 313 | | 121 | 2 | 605 | 3539 |
| 31 | 97 | 957 | 8986 | 98 | | | 305 | 27 | 8200 | 10756 |
| 32 | | | 3 | 15 | 57 | 48 | 20 | 23 | 98 | 2102 |
| 33 | | 14 | | 17 | 23 | | 34 | 1 | 60 | 2776 |
| 34 | 335 | | 118 | 81 | 128 | 5 | 40 | 37 | 498 | 4888 |
| 35 | 509 | 221 | 1146 | 82 | 150 | 62 | 336 | 145 | 2237 | 8574 |
| 36 | 14 | | 1100 | 14 | 448 | | 408 | 1238 | 788 | 12108 |
| 37 | | | | 44 | 263 | | 6 | 393 | 167 | 1365 |
| 38 | 29 | | 2906 | 209 | 156 | | 730 | 387 | 3302 | 25448 |
| 39 | | | | 30 | | | 56 | 612 | 587 | 1046 |
| 40 | 285 | | 5480 | 41 | 10 | | 133 | 138 | 5812 | 10044 |
| 41 | 24 | | 839 | 4 | 13 | 15 | 31 | 159 | 737 | 2012 |
| 42 | 3267 | | 10 | 17 | 118 | 239 | 119 | 54 | 3717 | 18771 |
| 43 | 172 | | 114 | 8 | 3 | | 81 | 84 | 281 | 2863 |
| 44 | 48 | | | | 5 | | 24 | 5 | 72 | 4825 |
| 45 | 1138 | | 434 | | 88 | 14 | 340 | 1338 | 686 | 12643 |
| 46 | | | | 13 | 2 | 1 | 4 | 8 | 14 | 588 |
| 47 | 203 | 11 | 4401 | 80 | 11 | | 148 | 697 | 4135 | 10577 |
| 48 | 377 | | | 29 | 184 | | 41 | 412 | 152 | 1522 |
| 49 | 1008 | 62 | 5 | 38 | 7 | | 82 | 340 | 885 | 2907 |
| 50 | 1735 | 74 | 417 | 48 | 156 | 101 | 285 | 45 | 2978 | 9100 |
| 51 | 944 | | | 47 | 73 | 15 | 278 | 345 | 818 | 14093 |
| 52 | 22 | | 264 | 5 | 3 | | 36 | 2 | 319 | 2497 |
| 53 | | | | 4 | | | 39 | 50 | 16 | 1173 |
| 54 | 2806 | | | 913 | | | 35 | 315 | [illegible] | 32653 |
| 55 | 3273 | | 318 | 566 | 1474 | 31 | 2357 | 479 | 7541 | 30133 |
| 56 | | | | 29 | 82 | 94 | 4 | | | 2016 |
| 57 | 11 | | | 58 | 6 | | 456 | 54 | 361 | 5630 |
| 58 | 281 | | 492 | 33 | 861 | 326 | 812 | 459 | 2520 | 15652 |
| 59 | 1 | | | 1 | 13 | 15 | 66 | 108 | 11 | 632 |
| 60 | 9986 | | 1323 | 243 | 966 | 509 | 873 | 892 | 12236 | 23054 |
| 61 | 10751 | | 201 | | 463 | 655 | 55 | 49 | 12076 | 29968 |
| 62 | 348 | | | 30 | | 81 | 447 | 4 | 842 | 3665 |
| 63 | | | | [illegible] | | | 44 | 612 | [illegible] | 12817 |
| 64 | 838 | | | | 77 | 88 | 82 | | 1082 | 5454 |
| 65 | 11233 | 669 | 2425 | 178 | 1863 | 535 | 2987 | 24 | 19820 | 43749 |
| 66 | 414 | | 18 | | 154 | 8 | 6 | | 599 | 6357 |
| 67 | 12598 | | | | 326 | 114 | | | 13039 | 18208 |
| 68 | 5818 | | 354 | | 169 | 108 | | | 8447 | 10481 |
| 69 | | | | | | | 13 | | 13 | 2060 |
| 70 | 4377 | | | 30 | 23 | 61 | 350 | | 4719 | 7529 |
| 71 | 27157 | | 78 | | 152 | 425 | | | 27812 | 30150 |
| 72 | 91465 | 4958 | 6657 | 127 | 888 | 254 | 1807 | 860 | 87118 | 128318 |
| 73 | 15645 | | 584 | | | 246 | 35 | 62 | 16573 | 35078 |
| 74 | 8737 | 538 | 148 | | 247 | 275 | 88 | | 7036 | 13000 |
| 75 | 2499 | | 3427 | | 751 | 752 | 229 | | 7658 | 32506 |
| 76 | 53230 | 1844 | 281 | | 166 | 333 | 333 | | 56007 | 82399 |
| 77 | | | 8 | | 1430 | 4525 | | | 5864 | 22493 |
| 78 | | | | | 8810 | | | | 8810 | 7129 |
| 79 | | | 18 | | 88 | 173 | | | 290 | 1806 |
| 80 | | | 308 | | | | | 218 | 84 | 8577 |
| 81 | 18 | 1080 | 88 | 248 | 154 | 450 | 275 | 404 | 758 | 861 |
| | 5207 | 20 | | 14 | 3696 | | 263 | 13639 | 4433 | |
| | 6218 | | 24950 | 422 | 20036 | 25572 | 5798 | 898 | 87268 | 608800 |
| | 380358 | 34285 | 70321 | 2022 | 87350 | 38245 | 31410 | 28955 | 600000 | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

seems quite adequate for present purposes; finer differentiation of resources would seem most useful for the energy categories. If additional data is used, it would be wise to substitute a larger set of categories for a smaller set of Leontief categories, since the latter are considered exhaustive.

2. $COST_{I, J}$ - Data needed for this matrix is defined as the mean cost per unit of input J or value per unit of output J for industry I. The development of appropriate data for the matrix will be a considerably more difficult task than that required for the VALUE matrix. The most difficult problem in the development of an economic location model is the determination, for each resource, of the number of units of known weight used by an industry. The difficulty results from the fact that output of industries is customarily reported in dollar value, rather than unit terms, since value is a common denominator of all resources and products, whereas units produced are generally not comparable.

The task of specifying $COST_{I, J}$ is not an easy one, but the following procedure should provide an adequate basis for such specification. First, the task can be simplified considerably, since for most industries, the great proportion of inputs comes from about ten sources. Thus, estimations need be made only for the fewest inputs which comprise 80% of the total. Second, separate estimates of cost per unit for a resource should be made for each industry type using the resource, since in the case where resources are discrete objects, size of resource J object used will differ from industry to industry using the resource. This consideration is of importance because of the need to specify TRATE (input 3) on the basis of size.

For some industrial resources and outputs, the unit of output or input corresponds to a unit of weight or volume measurement, and the second consideration is of no great importance. This is most often the case with raw or basic resources such as water, iron, ore, coal, forestry products and food. In such cases COST data requirements may be fulfilled by determining the appropriate unit of measurement and the average cost of each such unit.[4]

[4][Possible sources for some of this data include those general sources listed in footnote 3 as well as publications by the Office of Business Economics of the Department of Commerce, and "National Income Supplement" and "U.S. Income and Output," both supplements to the Survey of Current Business.]

In the majority of industries, the method of determining cost data is not so straight forward. Most industries produce discrete objects (e.g. tables, cameras, cars, etc.). The variety of discrete objects can be rather substantial within a given industry, though the range is certainly not as great within an industry as between different industries. For resources of this type used by an industry it is thus necessary to estimate the average cost of a unit of average size used by the industry. Such information can either be accomplished by use of an expert acquainted with resource needs and costs in different industries, or by surveying companies of various industry types for the information.

3. $TRATE_{I,J}$ - For each filled cell of the COST matrix it will be necessary to have a corresponding filled cell of the TRATE matrix which estimates the mean cost of transporting a unit of input or output J a standard unit of distance (1 mile). This cost will vary according to the weight (and value) of the unit in question. For the calculations of the model to be of any use, it is important that the unit of input or output used to estimate transportation costs correspond exactly to the unit of input or output for which COST was estimated. Thus, if cost estimates are made on the basis of a motor of certain size, the cost of shipping that motor should be used as TRATE. Estimates should take into account the type of transportation likely to be used for the particular resource.

Determination of transportation costs should be a relatively simple matter. It requires that transportation lines actually serving the Indian area be consulted concerning their rate schedules. Once these schedules have been obtained, it is necessary to determine the average cost per mile of transporting a specified unit of resource or product. It may be argued that transportation costs are not a linear function of distance - that the greater the distance a unit of resource is transported, the less the cost per mile of transporting that unit will be. Since this is indeed the case, when average transportation costs per mile are determined, it is important that they be computed on the basis of the total distance over which the resources or outputs will be transported.

Transportation distances fall into two general categories. First, there are resources available on the reservation or from transportation nodes (railroad terminals or sidings, airports, truck terminals) on the reservation. Second, there are resources and outputs which must be transported through the nearest available off-reservation transportation node. In the first case, TRATE should be estimated on the basis of the average distance from the resource point to any other point on the reservation. In the latter case, it should be estimated on the basis of the distance from a central point on the reservation to the nearest adequate off-reservation transportation node.

4. $\text{FAROUT}_{I, J, K, L}$ - The estimation of distances of input sources and output distribution points from each grid square of the Indian area may most efficiently be accomplished by the following procedure.

First, all resource and output types should be mapped as to their points of origin. Natural resources (timber, water) will be available from a number of different areas of the reservation. Processed inputs, and natural resources not available on the reservation, will be available either from transportation nodes on the reservation or from some off-reservation transportation node.

Once source points or areas have been determined, it is a simple matter to measure, for each industry resource type, the distance from the nearest source of that input to each grid square. Distances should not be estimated "as the crow flies," but rather in terms of the number of miles the resource must be transported to reach a given grid square. For cases in which the grid square under consideration is not now served by a road, calculations should be based on use of a hypothetical access road from that grid square to the nearest road.

The matrix in its final form will not be filled, simply because it is necessary to estimate $\text{FAROUT}_{I, J, K, L}$ only for the resources and outputs J of industry type I for which $\text{COST}_{I, J,}$ and $\text{TRATE}_{I, J,}$ have also been estimated.

5. $\text{SUPLAB}_{K, L}$ - The availability of a ready supply of labor must be estimated for each grid square. On the assumption that it is possible to commute fifteen miles to a work site, the following code is suggested:

0=no labor concentration
1=grid square within 15 miles of a town 500
2=grid square within 15 miles of a town 1000
3=grid square within 15 miles of a town 2000

Should either the commuter distance or town size seem disproportionate to the size or total population of the Indian area, the definition may easily be altered to suit the particular conditions of the area. Whatever definitional decision is made should be followed in the classification of all grid squares in the area.

6. $TRASE_I$ - This index is used to give some basis for comparing on-reservation transportation costs to average transportation costs for a company of a particular industry type. Although the two figures will not be absolutely comparable, since all transportation costs will not have been computed for Indian area locations, the figures will give a valid basis for relative transportation cost differentials across industries, as long as the same method is used for computing TRASE for all industries. If the degree to which the model tends to underestimate transportation costs is determined, TRASE can be discounted by that percentage for all industry types so that costs within an industry will be comparable on an absolute basis.

The task of estimating average transportation costs requires two pieces of information for each industry type. First, it is necessary to know the total amount spent on transportation by each industry type. This data is readily available from Leontief's dollar-flow table.[5] Second, it is necessary to have a rough estimate of the total number of industries of each type. This information can be obtained from the 1958 Census of Manufactures.[6] The mean transportation cost for each industry type can then be computed by

$$TRASE_I = \frac{E}{N}$$

where E = transportation expenses in industry, and
N = number of companies in industry.

7. $TINDEX_I$ - The index of transportation intensiveness may be determined by dividing the amount spent for "transportation and warehousing" by the

[5] Leontief, op. cit., pp. 8-9.
[6] U. S. Department of Commerce, Census of Manufactures, 1958.

total amount spent for all inputs plus the amount spent for non-conpetitive imports plus value added by each industry type. This data is available in Leontief's dollar-flow chart.[7]

8. $\text{LINDEX}_I$ - The index of labor intensiveness for each industry type should be set equal to the total amount spent on labor in each industry divided by the total amount value of the industry's output. The latter data equals the sum of the column for each industry in Leontief's table.[8] That is, total value of output equals the sum of all inputs, non competitive imports and value added.

The amount spent on labor is not readily obtainable from any single source. However, Leontief uses such information in another of his publications and presents a table of source references for such data. The table is presented here for use in obtaining labor cost estimates.

[7] Leontief, op. cit., pp. 8-9.
[8] Ibid.

Source References for Labor Earnings[9]

| INDUSTRY | PROCEDURE | SOURCE |
|---|---|---|
| livestock, other agriculture | estimates of net income of farmers | U.S. Dept. of Agri., Agriculture Statistics, 1961. |
| forestry, agricultural services | wages and salaries of employees | U.S. Dept. of Commerce, Survey of Current Business, July, 1961. |
| manufacturing sectors | wages and salaries of payroll workers, salaries of administrative workers, and income of unincorporated business were summed | U.S. Dept. of Commerce, Census of Manufactures, 1958 and Survey of Current Business,* July, 1961. |
| trade and service sectors | same as for manufacturing | U.S. Dept. of Commerce, Census of Business and Selected Services, 1958; Bureau of Employment Security, Employment and Wages, 1958; U.S. Dept. of Commerce, Survey of Current Business,* July, 1961. |

*When the Survey of Current Business statistics were not detailed enough, the Income of Unincorporated Business was distributed among the 60-order sectors according to information given in Internal Revenue Service, Corporation Income Tax Returns, July 1958-June 1959.

PROCESS

A substantial amount of theoretical work has been done on the factors which determine industrial location. At the same time, some information is available about what factors are considered by firms to be important in determining locations. The problem of estimating benefits of alternative locations for industry types has received inadequate attention, however, simply because the factors which determine location are thought

[9] Leontief, Wassily, Input-Output Economics (New York: Oxford University Press, 1966), p. 221.

to vary widely from one industry type to the next. Thus, though studies have been made of individual industries, analyzing in terms of various theories the reasons for firms' location in various places, no predictive models have been developed to determine where, if firms came to a certain area, they would locate.

This model is a first attempt at such prediction; instead of trying to predict whether an industry will come to a particular area, it computes where an industry would locate if it came to a particular area. In addition, because of certain characteristics of Indian areas, many locational factors which would be of prime consideration in more developed or urbanized areas do not apply to the Indian situation. Thus, within a particular Indian area, labor relations and wage costs, ease of attracting out-of-area personnel, climate and other locational factors are not likely to differ from one location to another. Those factors which do differ are assumed to be associated either with transportation costs or labor supply. Thus, most non-economic locational factors (such as availability of education, police and fire, medical and other community facilities) will be present to the degree that there is a concentration of population and thus a supply of labor.

According to classical theory[10], economic locational factors are of three main types: market, materials and labor. The general theory is that manufacturing tends to locate near a market for its product. Savings which result from location near materials must outweigh the additional transportation costs resulting from location farther from direct access to a market. This is most often the case when there is a substantial weight loss due to processing, as in the mining and refining of iron ore. For labor to be an important consideration, the proportion of labor costs must be high in proportion to total costs; that is, the value added to the produce by labor must be high. This situation is most com-

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[10] A good review of location theory is presented in Edwin T. Cohn, Jr., Industry in the Pacific Northwest and the Location Theory (New York: King's Crown Press, 1954), Chapter I.

mon when large amounts of low-cost, semi-skilled labor or high cost, high-qualified labor are employed. Neither the information available about the labor supply in Indian areas, nor that about industry needs, is at present sufficiently detailed that labor costs in different locations can be formally weighed against transportation costs. The output of the model will, however, (as was noted in the discussion of outputs) make clear where labor is concentrated and to what degree a given industry depends on it.

All other economic costs of location may be integrated into one transportation factor, since both the pull of inputs and markets can be measured in terms of the costs of transporting inputs to the location, and outputs from the location. The different costs of energy and water resources at alternative locations are treated as transportation costs and are thus included in the overall transportation factor.

The Economic Location Model process, therefore, entails the computation of the amount of resources used by each industry type, from the dollar amount spent on resources and the cost per unit of resources. For each grid square location, the amount of a resource used, multiplied by the distance of that resource from the grid square, multiplied by the cost per mile of transporting the resource, yields the transportation cost for that resource and grid square. The sum of these resource transportation costs for all resources used by an industry gives the total transportation costs for an industry at a given grid square location.

The model calculates these transportation costs for each industry for all grid squares, and, while calculating, notes which locations have low transportation costs for a number of industries, and which industries have low transportation costs at a number of locations.

## PLANNING SUBPROCESS

As was mentioned in the discussion of objectives, the Economic Location Model serves both as an input to the School Location Model and as an information input for the development of an industrial development plan for the Indian area. To the degree that the latter objective is realized, output of the Economic Location Model becomes less useful for the projection of school location needs.

Several factors might cause the development plan to differ from the direct output of the Economic Location Model. First, some industries have a high degree of interindustry dependency; that is, there are advantages for location near other industries which provide key inputs either of materials or services. Such industries would be barred from location at many, if not all, reservation locations. Secondly, secondary, or non-economic, location factors, such as community facilities, may be specially developed as part of an industrial location plan, in order to attract industries to certain locations. Finally, Indian preference and support for alternative strategies of attracting industry may alter the types of industry for which location in the area is a serious possibility.

When these conditions, or any others which would alter the Reservation Location Development Map, apply, it is crucial that such plans be reported by those responsible for economic development planning to the BIA officials in charge of school location planning. In addition, if negotiations for industrial location are under way, the type of company and stage of negotiations should be described. In short, any modifications of the economic location situation should and must be made known to school planning officials, so that school locations may be planned with a regard to maximizing both educational benefits and incentives for industrial location.

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## BIA ECONOMIC PROJECTION MODEL

### Variable List

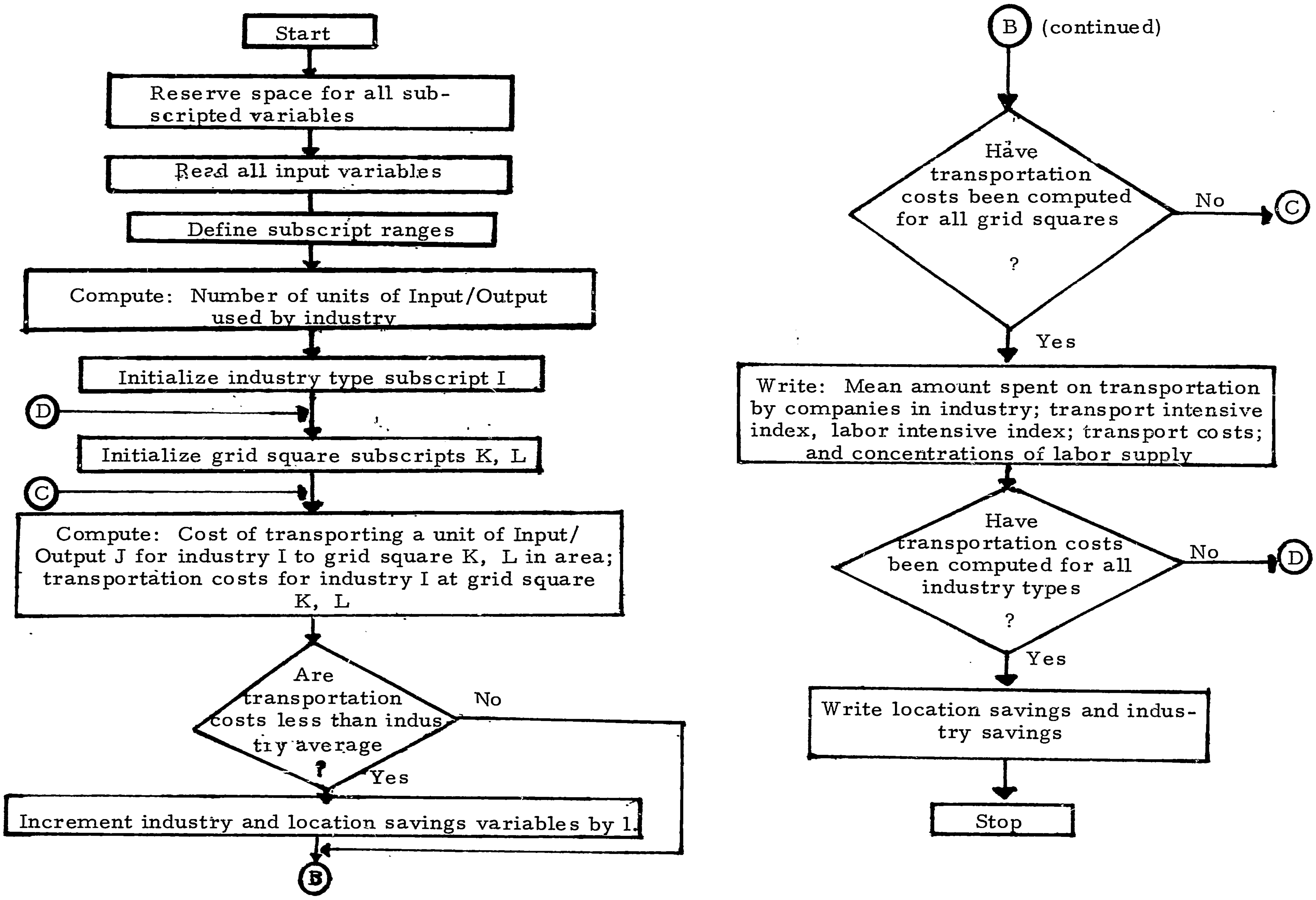
Inputs

| | |
|---|---|
| $VALUE_{I,J}$ | Mean amount spent for input J or total value of output J in industry I. |
| $COST_{I,J}$ | Mean cost/unit of input J or value/unit of output J for industry I. |
| $TRATE_{I,J}$ | Mean cost of transporting a unit of input (output) J/unit of distance. |
| $FAROUT_{I,J,K,L}$ | Distance of input supply or output distribution point from grid square K, L. |
| $SUPLAB_{K,L}$ | Code for labor supply: 0 = no concentration; 1 = grid square is within 15 miles of a town with population >500; 2 = population >1,000; 3 = population >2,000 |
| $TRASE_{I}$ | Total amount spent by industry on transportation/total number of companies in industry |
| $TINDEX_{I}$ | Transportation and warehousing input for industry I/ total value of output for industry I |
| $LINDEX_{I}$ | Total cost of labor for industry I/total value of output for industry I |

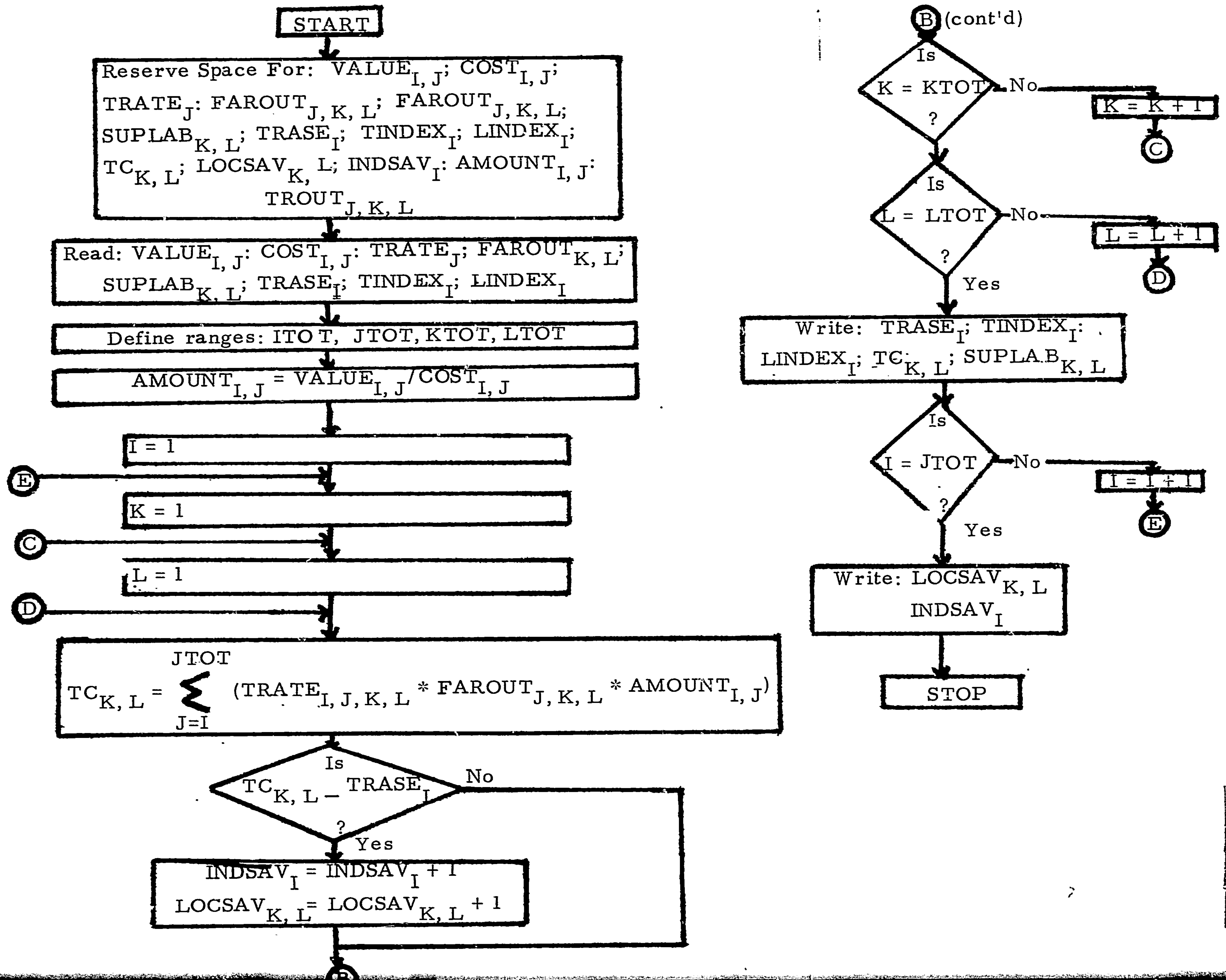
Outputs

| | |
|---|---|
| $TRASE_{I}$ | Total amount spent by industry on transportation/total number of companies in industry. |
| $TINDEX_{I}$ | Transportation and warehousing input for industry I/ total value of output for industry I. |
| $LINDEX_{I}$ | Total cost of labor for industry I/total value of output for industry I |
| $TC_{K,L}$ | Transportation costs map |
| $SUPLAB_{K,L}$ | Code for labor supply: 0 = no concentration; 1 = grid square is within 15 miles of a town with population >500; 2 = population >1,000; 3 = population >2,000 |
| $LOCSAV_{K,L}$ | Location savings map |
| $INDSAV_{I}$ | Industry savings number of locations. |

## BIA ECONOMIC PROJECTION MODEL--ENGLISH LANGUAGE FLOWCHART



BIA Economic Projection Model - Mathematical Flowchart



## Chapter V

## Facilities Location Model

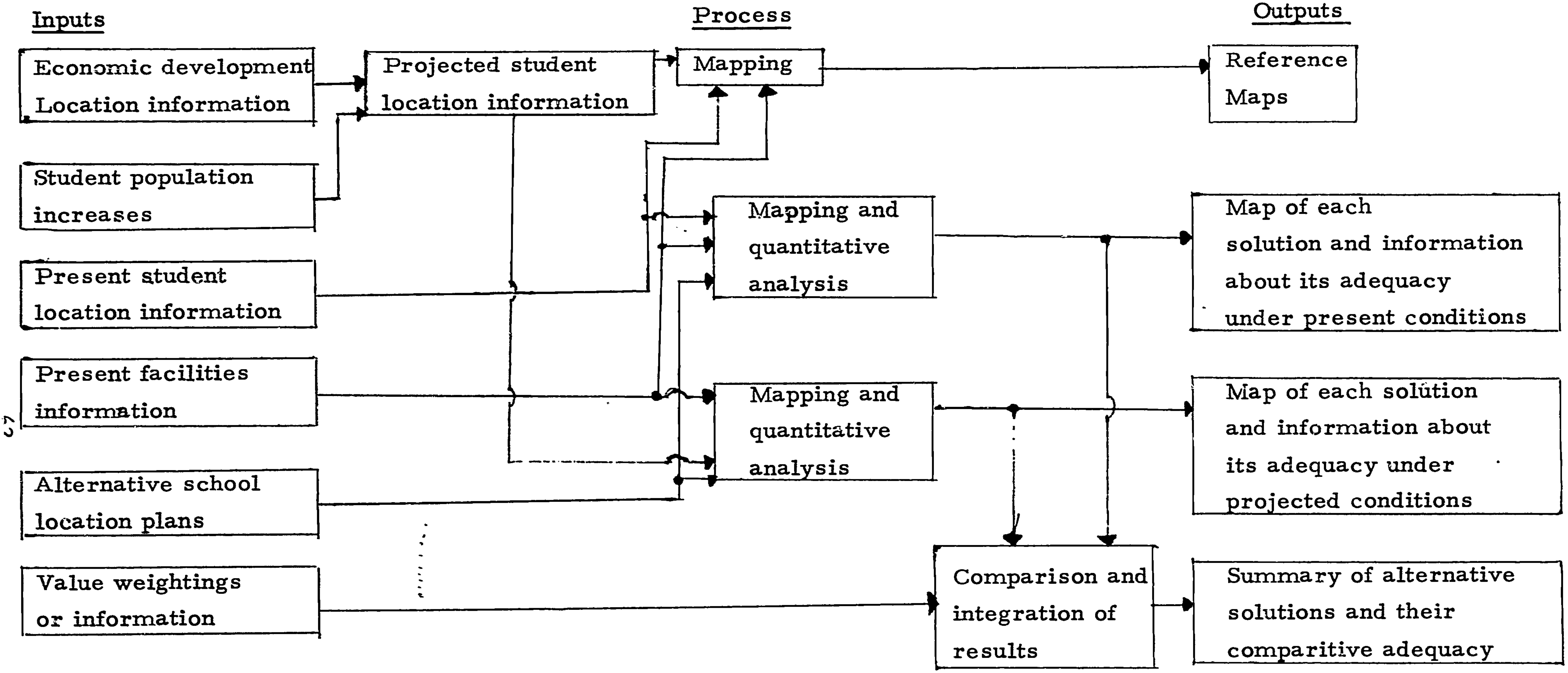
### DESCRIPTION OF OBJECTIVES

The Facilities Location Model is designed to be used as an evaluative tool in the planning process, rather than as an instrument to determine the optimal location of schools according to one set of programmed assumptions. The prime feature of this design is its ability to evaluate alternative plans, for location and use of facilities, which are proposed by BIA school planners. Each alternative plan is evaluated in terms of its adequacy in minimizing the distance of all students of all grades from schools, and in reducing the variation among schools the degree to which facilities are utilized. These tests of alternative plans are made both under present conditions and future conditions, as they are affected by economic development and population growth. All information and calculations for the model are performed by superimposing a grid of two mile by two mile squares on the Indian area and treating each square as a discrete unit. The grid is the same as that used in the Economic Projection Model (See Section 4.2.3).

The objectives met by the Facilities Location Model are as follows:

1. Use of knowledge about future economic and population conditions in determining the feasibility of plans.
2. Felxibility in allowing the user to program input assumptions.
3. Flexibility in allowing the user to propose a number of alternative solutions, each of which may have benefits of a nature which cannot be evaluated by the model; the model does not prescribe a "best" solution, as this would offer the planner no basis for evaluating deviations from that solution.
4. Evaluation of proposed school location plans in such a way as to give a comparative indication of their adequacy under a variety of conditions. Model outputs, inputs and the process linking the two were discussed in this section following the conceptual flow chart; a complete variable list and English language and mathematical flow charts are included in Appendix E.

# FACILITIES LOCATION MODEL



## OUTPUTS

Information printed by the Facilities Location Model is of three general types. First, reference maps provide basic information about present and projected locations of students, present locations of schools, and projected economic development. Second, maps and adequacy information under present and projected conditions are printed for each solution. Finally, a summary of all alternative plans proposed and their comparative adequacy under present, projected, and a weighted combination of present and projected conditions, is presented.

The weighted combination permits the user to estimate the relative validity of present and projected information (and thus the confidence with which outputs of evaluations under these two conditions may be accepted), and then determines the relative value of alternative plans under a combination of present and projected conditions. The information presented by this weighting should not be regarded as real -- that is, the weighted combination of present and projected average pupil distance to his school does not yield an accurate statement of some intermediate average pupil distance to school. Instead, such information should be conceptualized as describing plans according to their adequacy under both present and projected conditions.[1] Thus, a plan which is entirely adequate under present conditions but very poor under projected conditions (or vice versa) would not appear as desirable, in the weighted combination variable as a plan which is fairly adequate under both present and projected conditions.

---

[1] The actual algorithm for the weighted combination is as follows:

$$DDD_{NEW} = PRESENT\ X(DD_{NEW,\ 1})^2 + FUTURE\ X\ (DD_{NEW,\ 2})^2$$

where DDD is the weighted combination under alternative plan NEW, $DDD_{NEW,\ 1}$ is the average pupil distance to school at present conditions and $DD_{NEW,\ 2}$ is the average pupil distance to school under projected conditions. PRESENT and FUTURE sum to 1.0 and represent the relaltive validity of present and projected information.

The reference maps present a simple reworking of input information and sample pages of output are therefore not presented here. Three types of reference maps are printed by the model. First, a map indicates present locations of students and school facilities, school size (maximum enrollment), and grade range. A second grid square reference map shows projected student locations and the same information about present schools. For the third reference map, the model prints projected economic development and the same information about present schools.

For each alternative plan, the model prints a map of the proposed plan including location of schools by grid square, their maximum enrollments, and grade ranges. Depending upon whether the evaluation of the plan is according to present or projected student locations, the map includes one or the other of these locations. As may be seen from the sample output included on the following pages, the model also prints the enrollment, average direct distance of students projected to be attending the school, and the percentage of maximum capacity used, for all grades in all schools. Since the school plan, with its maximum enrollment specified, may not be able to accommodate the entire student population, the model also prints the population for each grade for each grid square which could not be accommodated by the schools under the alternative plan. Finally, the enrollment, average distance of pupils' homes from school, and the percentage of maximum capacity now used is presented for each school and for the entire area being served by the plan.

After output for each alternative plan is presented, the model prints summary information for all alternative plans, rank ordering them by their adequacy in terms of minimizing mean pupil direct distance from school. Using this information, the planner can eliminate those alternatives which fail to meet a criterion of distance minimization, and may choose among other plans according to such criteria as economic and political considerations, accessibility, and cost of construction at locations. The planner may wish to use the model repeatedly by revising the acceptable plans, developing several variations, and testing these new alternatives. He may also wish to vary the assumptions of enrollment increase, economic development, and so forth, to test a group of plans under a variety of conditions. Such changes must be included in the model's inputs, which are discussed below.

## FACILITIES LOCATION MODEL
## SAMPLE OUTPUT

AREA: MESA VERDE

PLAN 2 EVALUATED UNDER PRESENT CONDITIONS.

### MAP OF THE AREA

(top number in each grid square gives number of students x 10 in that square; bottom number with asterisk is number of schools located in that grid square)

| Grid Square vertical \ Grid Square horizontal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 3 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 3 | 0 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 4 | 0 | 1 | 2<br>2* | 1 | 1 | 1 | 1 | 1 | 2<br>3* | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 5 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| 6 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 1<br>4* | 1 | 0 | 0 | 0 |
| 7 | 0 | 1 | 1 | 2 | 3 | 4 | 3 | 2 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| 8 | 0 | 1 | 1 | 1 | 3 | 5<br>1* | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| 9 | 1 | 1 | 1 | 1 | 2 | 4 | 2 | 1 | 1 | 1 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 |
| 10 | 0 | 1 | 1 | 1 | 2 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 0 | 0 |
| 11 | 0 | 1 | 1 | 1 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| School Number | Maximum Enrollment | Serving Grades |
|---|---|---|
| 1 | 350 | 7-12 |
| 2 | 200 | 1-6 |
| 3 | 200 | 1-6 |
| 4 | 180 | 1-4 |

FACILITIES LOCATION MODEL

SAMPLE OUTPUT, P. 2

EVALUATION INFORMATION BY SCHOOL AND GRADE

| School | Grade | Enrollment | % of Max. Enrollment | Mean Direct Distance to School |
|---|---|---|---|---|
| 1 | 7 | 65 | .98 | 5.37 |
| | 8 | 60 | .92 | 5.11 |
| | 9 | 60 | .92 | 5.82 |
| | 10 | 50 | .87 | 4.91 |
| | 11 | 50 | .87 | 5.73 |
| | 12 | 40 | .82 | 5.17 |
| 2 | 1 | 35 | .97 | 4.86 |
| | 2 | 35 | .97 | 4.39 |
| | 3 | 35 | .97 | 4.52 |
| | 4 | 30 | .94 | 4.35 |
| | 5 | 30 | .94 | 5.11 |
| | 6 | 30 | .94 | 4.91 |
| 3 | 1 | 35 | .95 | 3.98 |
| | 2 | 30 | .92 | 4.11 |
| | 3 | 35 | .95 | 4.06 |
| | . | . | . | . |
| | . | . | . | . |
| | . | . | . | . |
| | . | . | . | . |
| | etc. | etc. | etc. | etc. |

FACILITIES LOCATION MODEL

SAMPLE OUTPUT, P. 3

GRID SQUARE POPULATIONS NOT ACCOMODATED BY PLAN: NONE

EVALUATION INFORMATION BY AREA AND SCHOOL

| | Enrollment | % of Max. Enrollment | Mean Direct Distance | Population Not Accomodated |
|---|---|---|---|---|
| | 880 | .93 | 5.17 | 0 |
| Area School | | | | |
| 1 | 325 | .93 | 5.43 | |
| 2 | 195 | .98 | 4.45 | |
| 3 | 175 | .88 | 4.14 | |
| 4 | 185 | .93 | 5.11 | |

FACILITIES LOCATION MODEL

SAMPLE OUTPUT, P. 4

RANK ORDER OF ALTERNATIVE PLANS' MINIMIZATION OF MEAN PUPIL DISTANCE TO SCHOOL UNDER PRESENT CONDITIONS

| Plan No. | Mean Direct Pupil Distance | % of Maximum Enrollment |
|---|---|---|
| 3 | 4.97 | .91 |
| 2 | 5.17 | .93 |
| 1 | 6.04 | .92 |
| 4 | 6.11 | .91 |

RANK ORDER OF ALTERNATIVE PLANS' MINIMIZATION OF MEAN PUPIL DISTANCE TO SCHOOL UNDER PROJECTED CONDITIONS

| Plan No. | Mean Direct Pupil Distance | % of Maximum Enrollment |
|---|---|---|
| 2 | 4.86 | .97 |
| 3 | 5.02 | .99 |
| 1 | 5.93 | .94 |
| 4 | 5.97 | .93 |

RANK ORDER OF ALTERNATIVE PLANS' MINIMIZATION OF MEAN PUPIL DISTANCE TO SCHOOL UNDER WEIGHTED PRESENT AND PROJECTED CONDITIONS

| Plan No. | Mean Direct Pupil Distance |
|---|---|
| 3 | 4.99 |
| 2 | 5.06 |
| 1 | 5.98 |
| 4 | 6.04 |

INPUTS

The Facilities Location Model requires a variety of inputs, many of which necessitate development of policy decisions and plans by the BIA. Other inputs are available as outputs from other models in the present series. One input, the present grid square locations of students, requires data gathering by the user. Each input, its characteristics and its source are discussed below.

1. $SCHOOL_{I,J}$ - a matrix of basic information about each of the present BIA schools in the area. The subscript I denotes an index number unique to each school, while the J subscripts denote information about each school I. Such information includes the school's grade range, its maximum enrollment, its grid square location, and the maximum enrollment allowable for each grade. This information should all be presently available in the area, except for the grid square location of the school which can easily be determined after the grid of two-mile-by-two-mile squares is superimposed on a map of the area and integers assigned sequentially vertically and horizontally to the coordinates.

2. $ECON_{K,L}$ - an index of economic development potential for each grid square (K, L). This variable is available directly as output from the Economic Projection Model and is discussed in Section 4.2.3. The user of the present model may wish to modify the index for particular grid squares to reflect new conditions or special consideration of economic development potential for certain grid squares. Such modification will be most usefully executed in consultation with persons knowledgeable in the economics of the area.

If output from the Economic Location Model is not available, this variable should be estimated by consultation with persons knowledgeable in the area's economics. Use of this latter method will probably decrease the accuracy and validity of the information, and Facilities Location Model inputs WEIGHT, PRESENT and FUTURE (discussed below) should be modified accordingly.

3. $SNOW_{K,L}$ - the numbers of students presently in grid square (K, L). This information will have to be gathered by the user. Depending upon

the degree of accuracy desired, he may either make a census of grid square student population, or use some less time-consuming and less expensive method. One such method would involve determining the total number of students in the area from total school enrollments (including boarding school enrollments) and allocating these students according to general knowledge: 1) where concentrations of population exist, of approximately how large these concentrations are: and 2) where there are no concentrations of population, what the approximate density of population is. This method, if used carefully, could yield information almost as accurate as that achieved by census, and easily accurate enough for use in the model.

4. $POPUP_M$ - the expected population increase in grade M for the entire area. This input can be readily obtained as an output from the Enrollment Projection Model (described in Section 4.2.1). The user of the present model has the choice here of deciding for how many years in the future he wishes to test the alternative school plans. Such a choice should be a function of the number of years the plan is designed to accommodate, but the user should be snesitive to the fact that accuracy of population projection declines as the number of years into the future for which it is made increases.

5. WEIGHT - the weighting of use of the economic development potential variable ($ECON_{K, L}$) in the computation of the future population distribution of students. The Facilities Location Model is designed to distribute student population increases on the basis of two factors: 1) the present location of students, and 2) the likelihood of economic development in each grid square location. WEIGHT represents the percentage of population increase which will be distributed to locations on the basis of the latter factor. Its estimation should be based on two considerations.

First, the variable should represent the user's estimation (on a 0.00 to 1.00 scale) of the importance economic development will play in the future location of students. If the area is economically relatively static, WEIGHT will be low; while if it is known that economic development is taking place, the estimation should probably be somewhat higher. The range of WEIGHT (i.e., the importance of economic development) should probably be from 0.10 to 0.50.

Second, the first estimate should be adjusted by the user's belief in the accuracy of both $ECON_{K, L}$ and $SNOW_{K, L}$. Each of these variables is felt to be equally accurate, WEIGHT should not be changed, but if one index or the other is known to be significantly more accurate, WEIGHT should be adjusted accordingly. Such adjustment should probably not exceed $\pm 20$ percent of the first estimate.

6. $SCHNEW_{NEW, I, J}$ - the alternative plan characteristics of each school in plan NEW. This variable corresponds in content to the SCHOOL matrix of information about present schools. For each alternative plan NEW, a list of schools will include for each school I, the grade range, maximum total enrollment, grid square coordinate location and maximum enrollment allowed for the school in each grade M.

It is by use of this variable that the planner may specify any number of alternative plans for location and use of facilities. Each plan should include existing schools which will be kept in the future (their grade ranges and other characteristics may be modified) as well as school facilities planned to be constructed in the area. Thus, specification of this matrix represents the basic task of location and use planning.

Only one limitation is attached to formulation of plans. Since the model distributes grid square populations by grade, it is important that the maximum enrollment allowed in each grade in each school be kept in roughly the same proportion to maximum enrollment of the school as size of student population in the area for that grade is to total student population. This will insure that grid square grade-specific populations are allocated proportionately to the schools.

7. $GRADE_M$ - the percentage of the population presently in grade M. This variable can be determined from present enrollment records. It should be specified such that the sum for all grades equals 1.00.

8. BOARD1 and BOARD2 - the percentages of area students in boarding schools now (1) and in the future (2). BOARD1 requires an estimation

of the present actual percentage, while BOARD2 estimation permits the user to make a policy decision concerning whether sending students from the area to boarding school should be increased, kept at its present level, or phased out.

9. PRESENT and FUTURE - weights of present and future distance projections used in computing the combined distance factor for all alternative plans. These weights are used according to the algorithm given in footnote 1. If the user wishes to give equal weight to the solutions under present and projected conditions, both PRESENT and FUTURE should be set to 0.50. Deviations from 0.50 will give more importance to the adequacy of the alternative plan under either present or projected conditions. A decision to deviated from equal weights should be made on the basis of validity of projected information and desire to make the plan more responsive either to present or projected conditions.

PROCESS

Though the model is described in detail in Appendix E, a brief non-technical discussion here may be of interest to the general user. The model reads all information except alternative plans, computes projected student locations on the basis of present student locations and economic development, and then prints the various reference outputs.

The plan then reads all information about an alternative plan and computes for each grade the distance of each grid square from each school serving that grade. These distances are then rank ordered and grade-specific population for each grid square distributed to schools by that rank order. This method insures that students for whom one school has a clear distance advantage over another get to attend the closest school. As the distance advantage of one school over another for a grid square decreases, the school which students attend becomes of less crucial importance.

Once students for all grades and grid squares have been distributed under an alternative plan, the model prints out information about the alternative plan's present and projected adequacy both by school and for the area. The model then recycles to evaluate another alternative plan.

After all alternative plans have been evaluated, the model computes the weighted combination of present and projected adequacy and then rank orders all alternative plans by: 1) their present average distance of students to schools; 2) their future average distance to schools; and 3) the combination of 10 and 2). This is the last step in the operation of the model.

## FACILITIES LOCATION MODEL

### Variable List

<u>Input Variables</u>

| | |
|---|---|
| $SCHOOL_{i,j}$ | Information about school I for item j |
| j = 1 | Minimum grade of school |
| j = 2 | Maximum grade of school |
| j = 3 | Enrollment |
| j = 4 | First coordinate of grid square (K) |
| j = 5 | Second coordinate of grid square (L) |
| j = 6, . . . , 17 | $SCHOOL_{i,j} = ENMAX_{i,m}$ the maximum enrollment allowed for school i in grade M |
| $ECON_{K,L}$ | An index of economic development potential for grid square (K, L) |
| $SNOW_{K,L}$ | The numbers of students presently in grid square (K, L) |
| $POPUP_M$ | The expected population increase in grade M for the entire area |
| WEIGHT | The weighting for the economic development potential component in the computation of the future population |
| $SCHNEW_{NEW,i,j}$ | The alternative (or planned) school characteristics; Corresponds to $SCHOOL_{i,j}$ for the future |
| $GRADE_M$ | The percentage of the population presently in grade M |
| BOARD1<br>BOARD2 | Percentages of students in boarding school now (1) and in the future (2) |
| PRESENT<br>FUTURE | The weights of the present and future projections in computing the combined advantage factors |

<u>Output Variables</u>

| | |
|---|---|
| $ENROL_{i,M}$ | --the enrollment in grade M, school i |
| $DIS_{i,M}$ | the average distance students in grade M must travel to school i |
| $EN_{i,M}$ | the percentage of capacity filled for grade M, school i |
| $T_{i,NEW,F}$ | the total enrollment of school i, plan NEW, present and future |
| $D_{i,NEW,F}$ | the average distance traveled to school i, plan NEW, present and future |

Facilities Location Model
Output Variables -- cont.

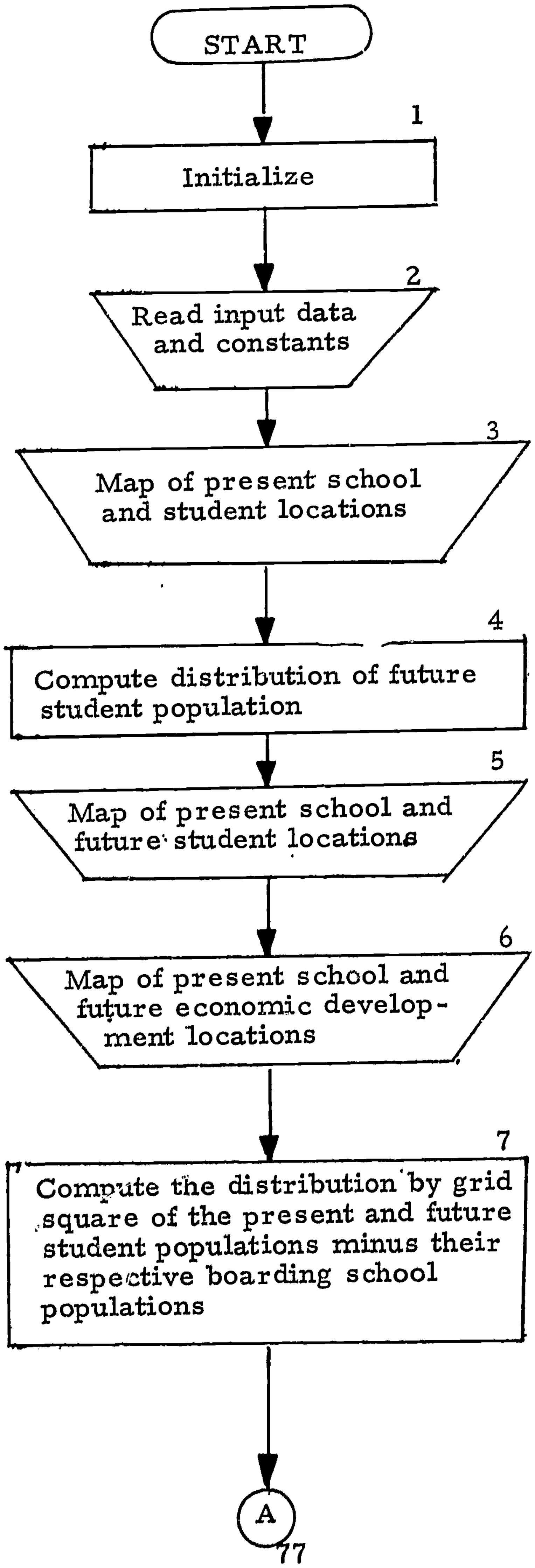
| | |
|---|---|
| $EM_{i, NEW, F}$ | The percentage of capacity used, school i, plan NEW, present and future |
| $TT_{NEW, F}$ | The area enrollment, plan NEW, present and future |
| $DD_{NEW, F}$ | The average distance traveled, plan NEW, present and future |
| $E_{NEW, F}$ | The percentage of capacity used, area, plan NEW, present and future |
| $DDD_{NEW}$ | Weighted average distance, weighting present and future populations |

Intermediate Variables

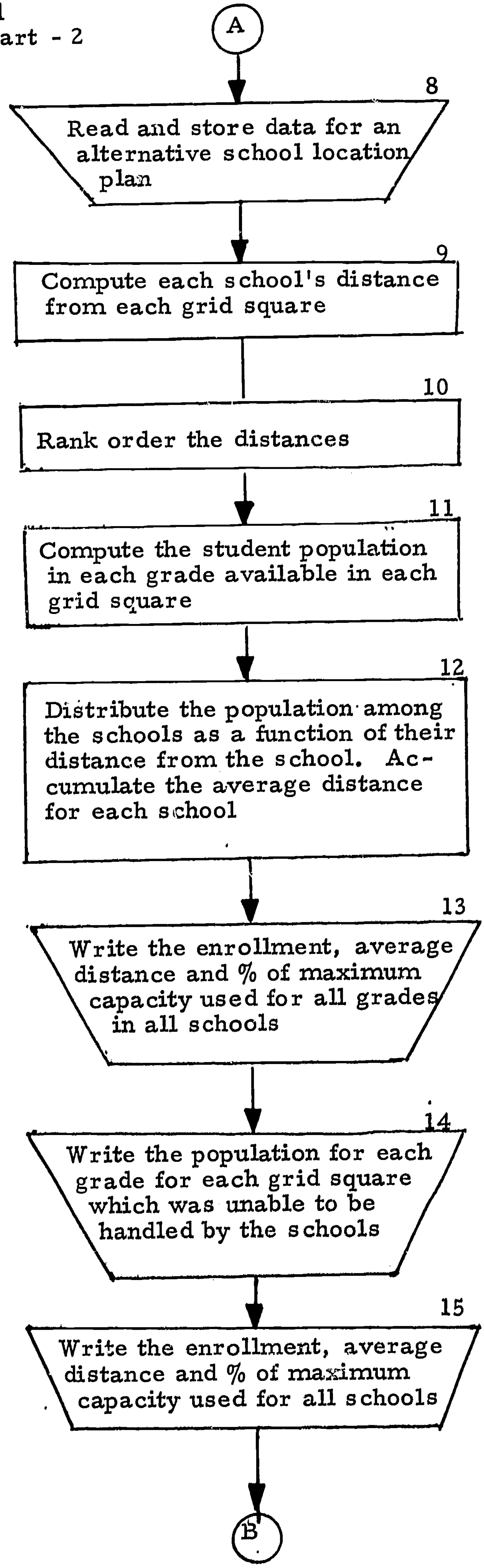
| | |
|---|---|
| E | Total index of economic development potential |
| $PE_{K, L}$ | The percentage of the economic development potential in each grid square |
| STOTAL | The total number of students at present |
| PUTOT | The total expected student increase |
| $SPROJ_{K, L}$ | The projected number of students per grid square |
| $SNOWP_{K, L}$ | The present number of students minus boarding school cases |
| $SPROJP_{K, L}$ | The future number of students minus boarding school cases |
| $ADVAN_{i, K, L}$ | The distance from school i to grid square (K, L) |
| $POP_{M, K, L}$ | The number of students in grade M in grid square (K, L) |

FACILITIES LOCATION MODEL

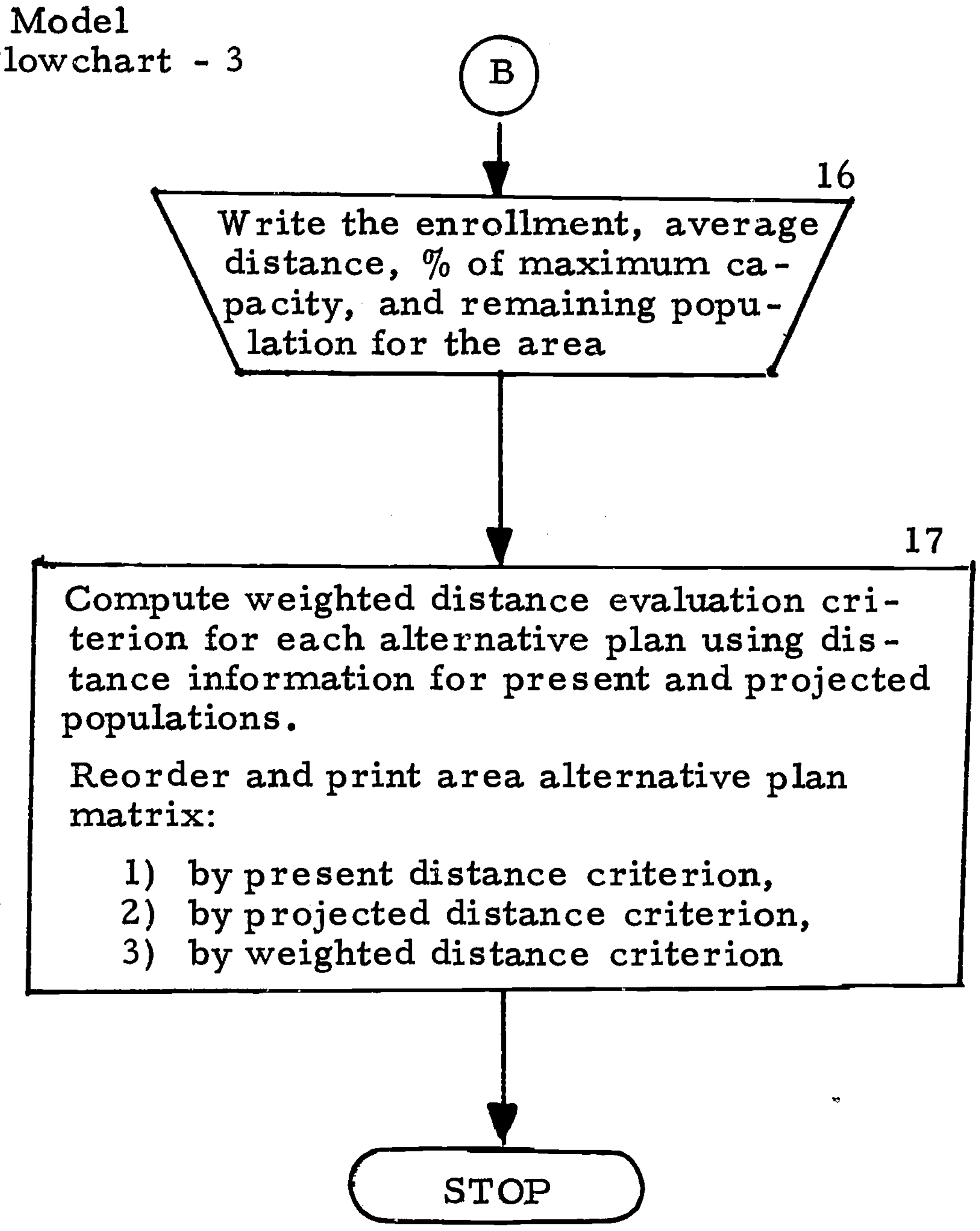
English Language Flowchart



Facilities Location Model
English Language Flowchart - 2

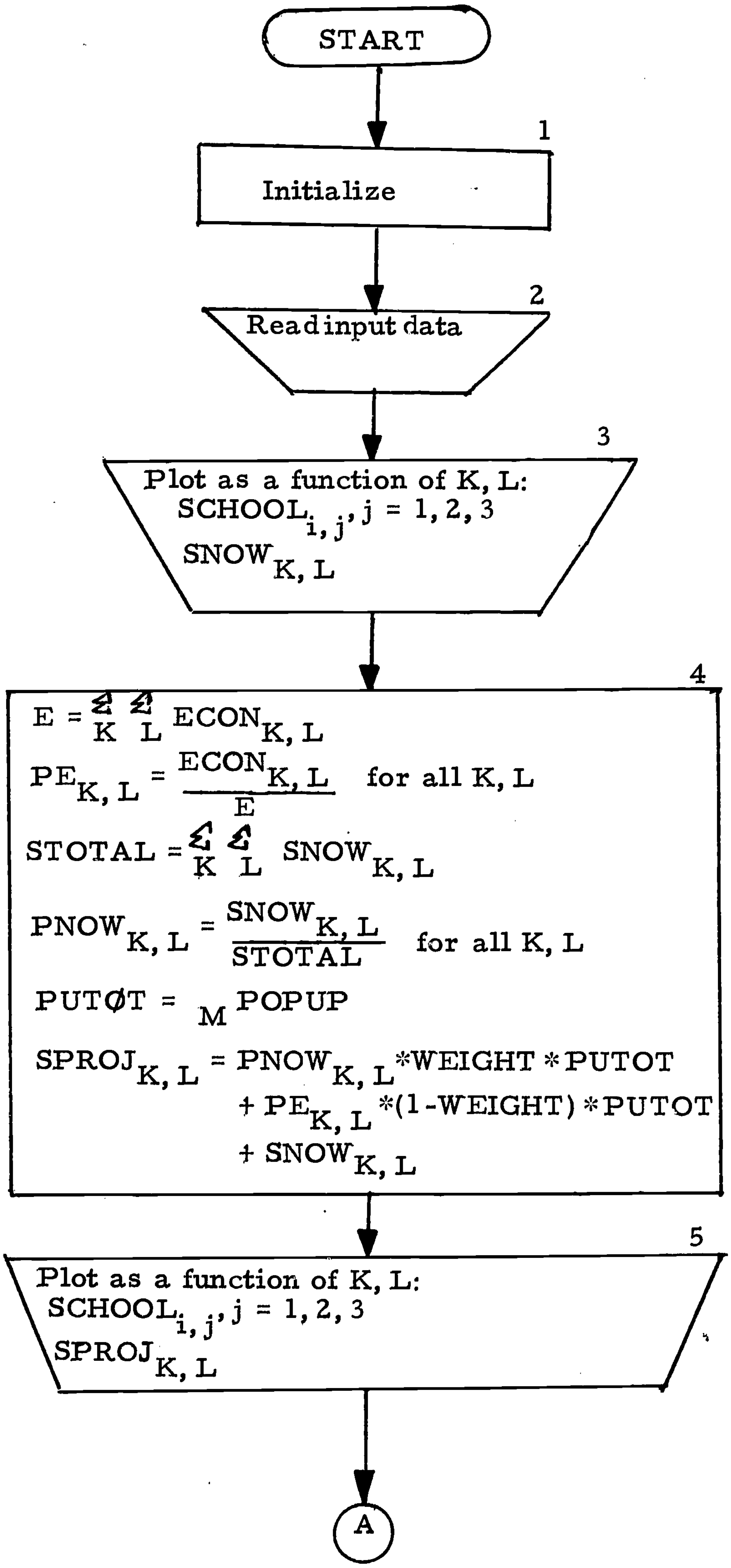


Facilities Location Model
English Language Flowchart - 3

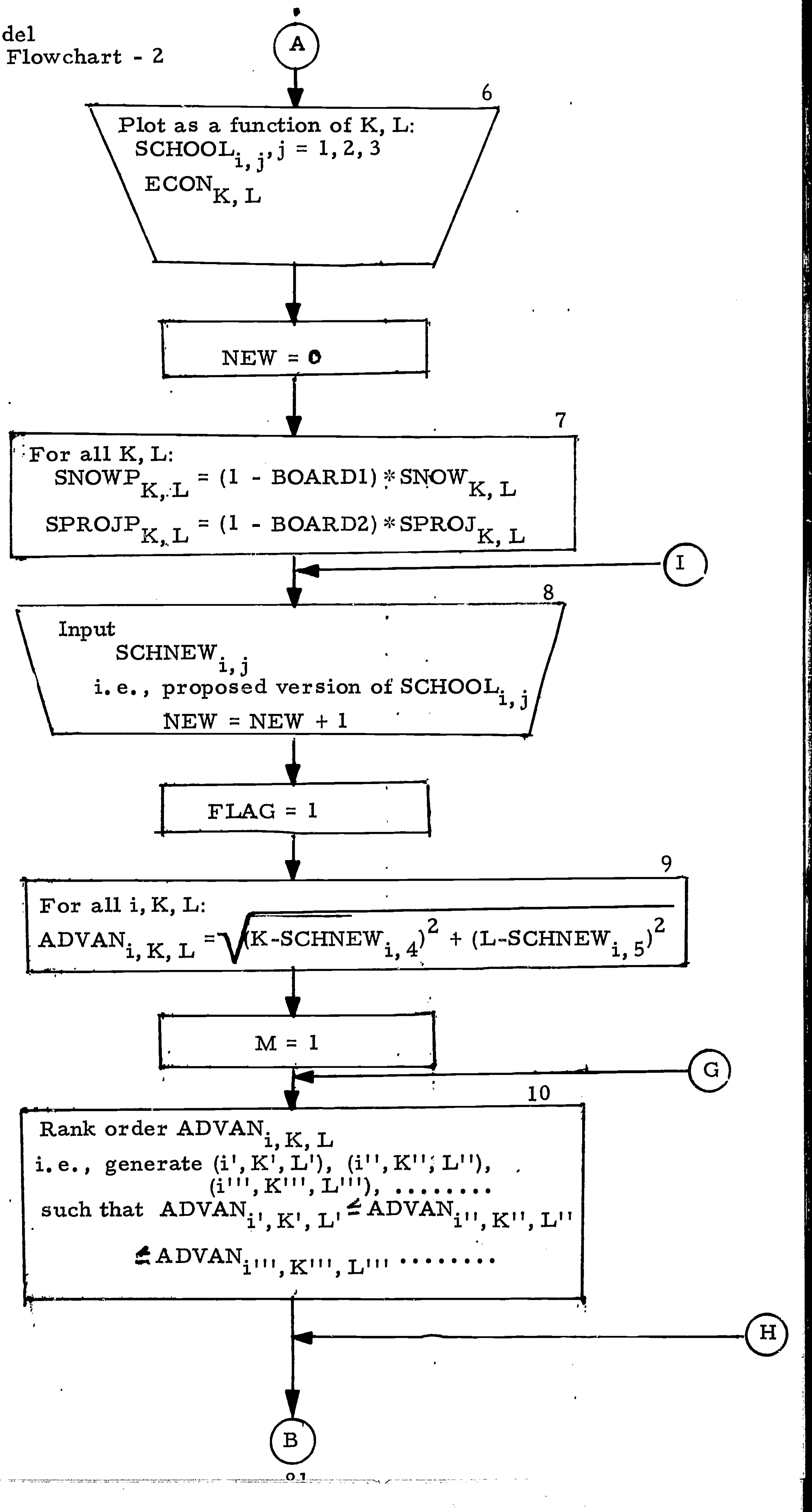


FACILITIES LOCATION MODEL

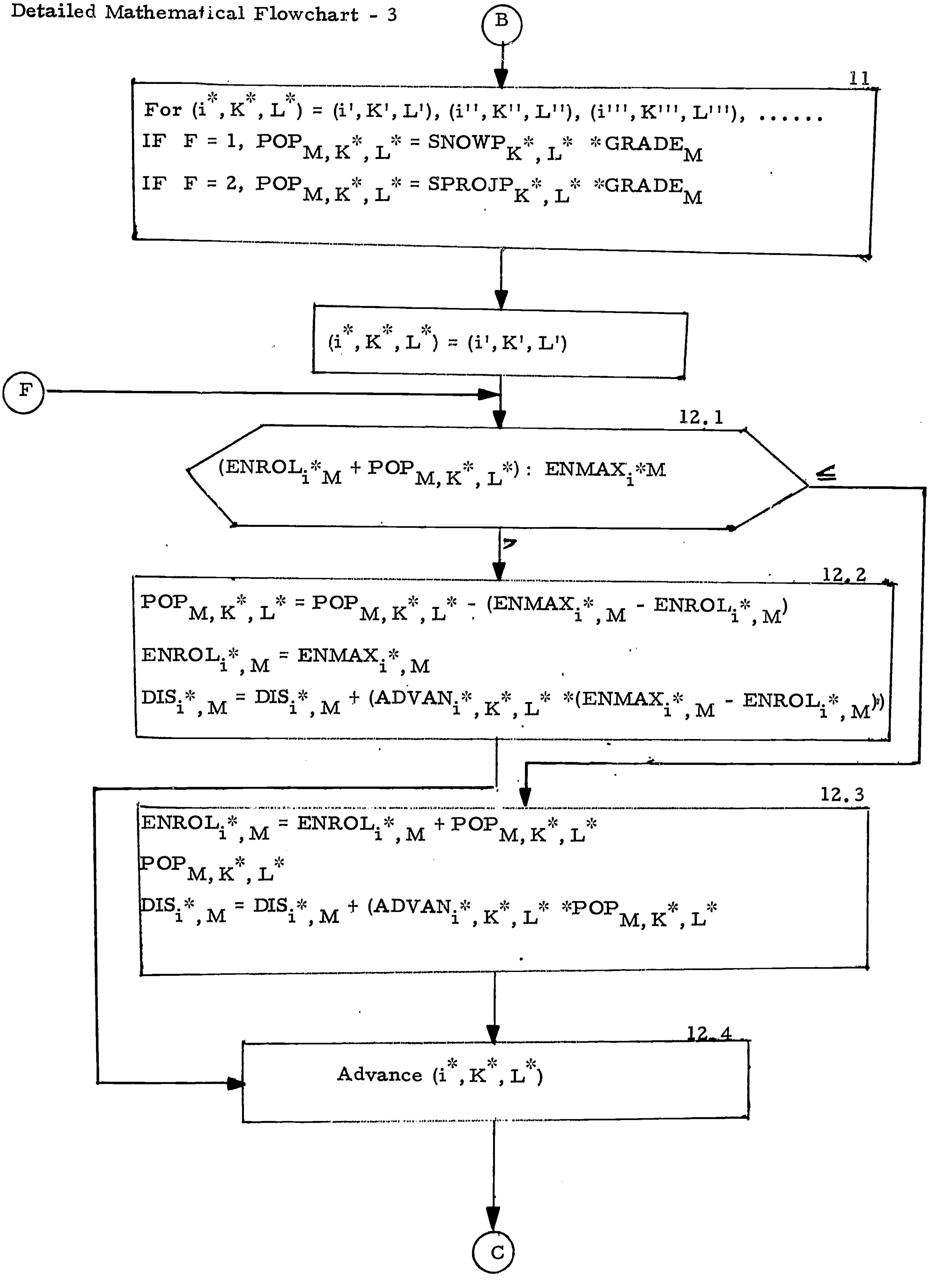
Detailed Mathematical Flowchart



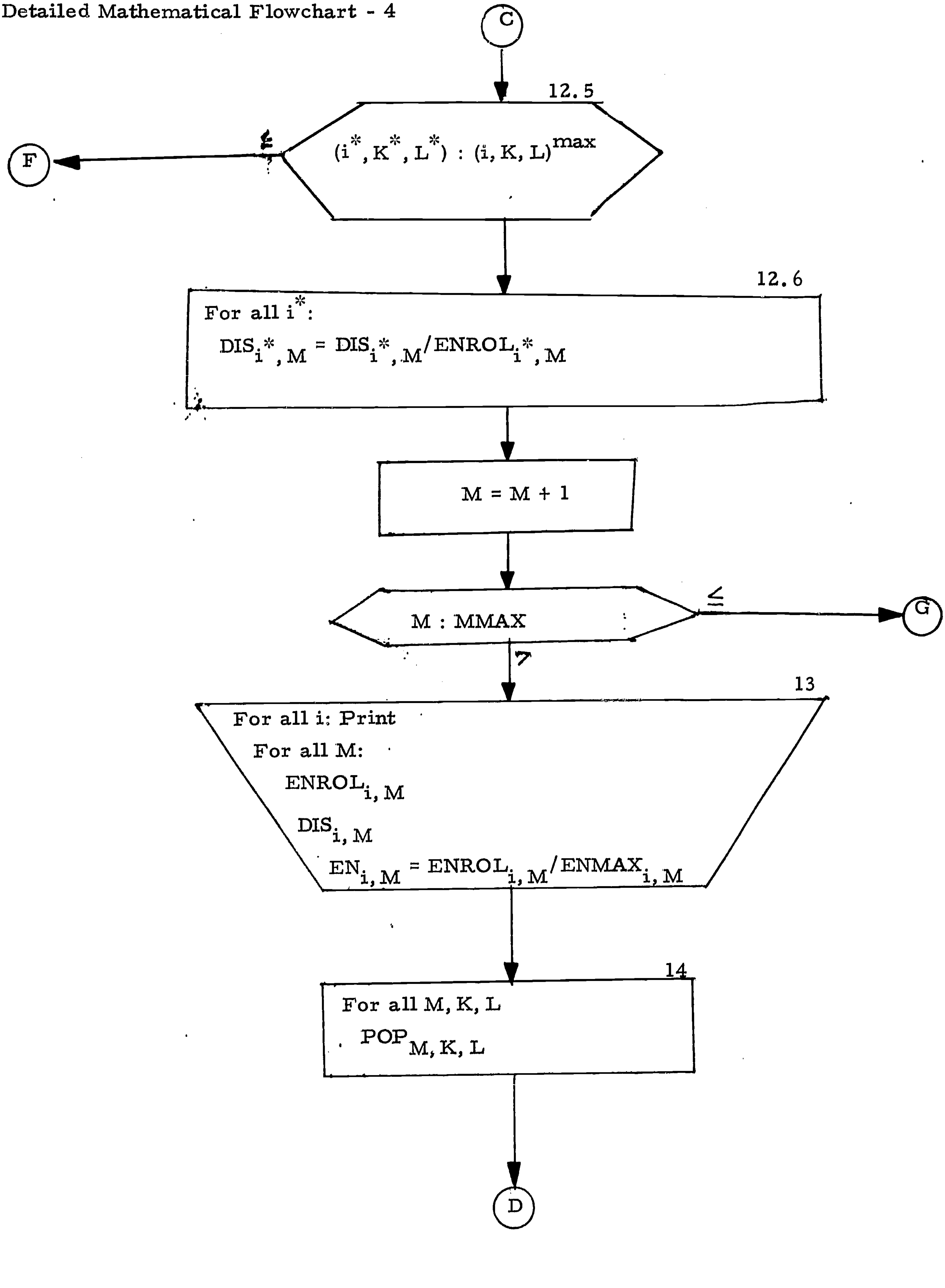
Facilities Location Model
Detailed Mathematical Flowchart - 2



Facilities Location Model
Detailed Mathematical Flowchart - 3



Facilities Location Model
Detailed Mathematical Flowchart - 4



Facilities Location Model
Detailed Mathematical Flowchart - 5

D

15

For all i: print

$$T_{i,NEW,F} = \sum_{M=1}^{MMAX} ENROL_{i,M}$$

$$D_{i,NEW,F} = \frac{1}{T_i} \sum_{M=1}^{MMAX} ENROL_{i,M} * DIS_{i,M}$$

$$EM_{i,NEW,F} = T_i/(TM_i = \sum_{M} ENMAX_{i,M})$$

16

Print:

$$TT_{NEW,F} = \sum_{i} T_i, \quad P_{NEW,F} = \sum_{M} \sum_{K} \sum_{L} POP_{M,K,L}$$

$$DD_{NEW,F} = \frac{1}{TT} \sum_{i} T_i * D_i$$

$$E_{NEW,F} = TT / \sum_{i} TM_i$$

F : 2 ($<$ → H; $\geq$ → next)

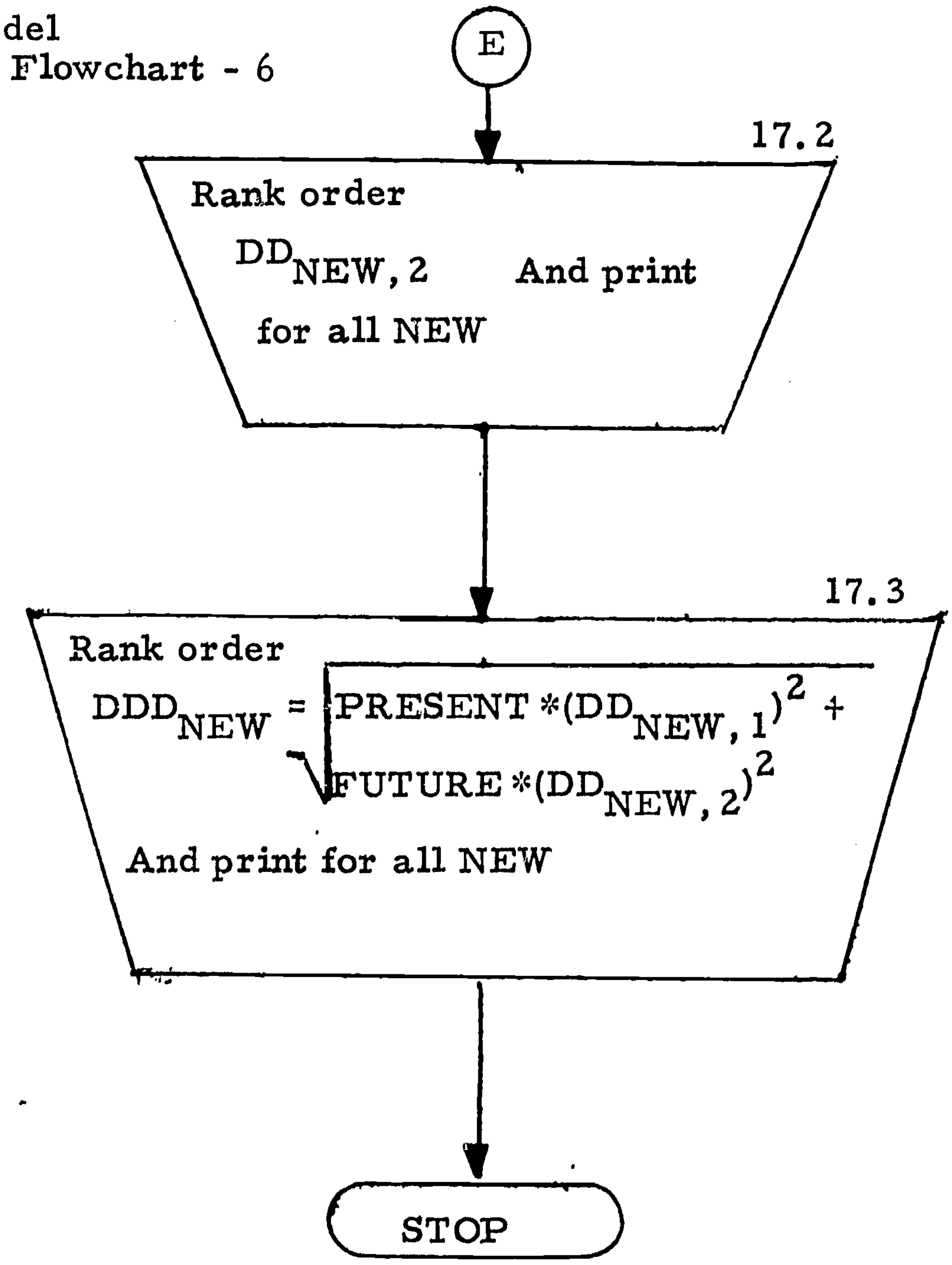
NEW : NEWMAX ($\leq$ → I; $>$ → next)

17.1

Rank order $DD_{NEW,1}$ And print for all NEW

E

Facilities Location Model
Detailed Mathematical Flowchart - 6



## Chapter VI

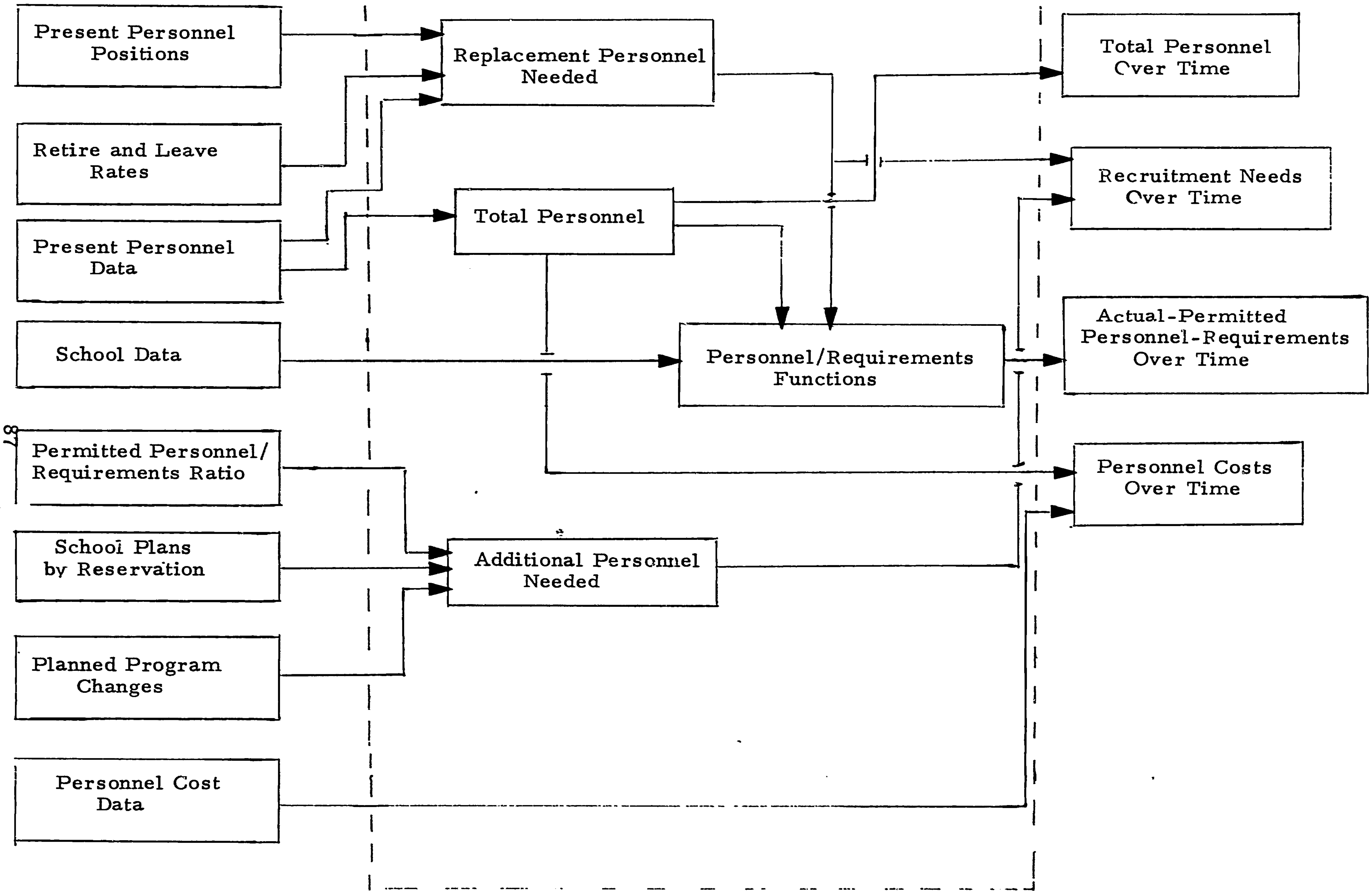
## Personnel Projection Model

### DESCRIPTION OF OBJECTIVES

Three principle objectives are served by the development of a Personnel Projection Model. First, it is useful to know what the allocation of personnel resources will be over time, and how this allocation compares with any standards set by the BIA for ratios of personnel to needs. Such information will be of prime importance in the analysis of alternative investment mixes for the BIA schools. Second, in the context of expanding school facilities and programs, it is important to know recruitment needs over time so that this function may be carried out more smoothly and efficiently. Finally, total personnel costs must be projected so that budgetary needs for future years may be estimated.

The Personnel Projection Model accomplishes these three objectives by using a variety of data, including present personnel and positions, retirement and leaving rates, school and program characteristics and plans, and personnel cost data. These inputs are combined by the model to produce information for each school as to total personnel, recruitment needs, personnel costs; data are computed both by job and in aggregate, and can be projected for any number of years inot the future. A discussion of model outputs, inputs and process follows the conceptual flow chart in this section; a variable list and English language and mathematical flow charts are included in Appendix E.

## BIA PERSONNEL PROJECTION MODEL



OUTPUTS

A sample output page for the Personnel Projection Model is presented on the following page. Output of this type will be printed for each school on a reservation and a similar page will include personnel projections for projected facilities not yet included in schools. In addition, summary output of the same type will be printed for the agency, area, and BIA.

The output will state the fiscal year and unit of organization for which the projection is being made. A list of job categories, total personnel, costs, and actual-permitted personnel/requirements ratio comparison (APRC) will then be listed. Total personnel and personnel costs will reflect the actual situation for the baseline year run of the model and will be projections for succeeding years.

The APRC deserves a more detailed explanation. The comparison is based on two ratios: the actual ratio of personnel to requirements and the permitted ratio of personnel to requirements. Both the method of calculating of the ratio and the permitted ratio are to be determined by BIA policy-makers. For example, it may be decided that for first-grade teachers the actual and permitted ratios should be based on total number of first grade teachers divided by the total number of first grade students. Having defined the ratio calculation method, policy makers then determine the permitted ratio which should not be exceeded. In the example under discussion, such a permitted ratio might be set at .10, or one teacher for every ten first grade students. The actual ratio is calculated by the model and divided by the permitted ratio to yield the APRC, which may thus be interpreted as a measure of actual personnel to requirements ratio compared with permitted personnel than are permitted under BIA policy will the ratio exceed 1.00.

BIA PERSONNEL PROJECTION MODEL - SAMPLE OUTPUT

Fiscal Year: 1969-1970

School: Mesa Verde Boarding

| Job Category | Total Personnel | Personnel Costs | Actual-Permitted Personnel/ Requirements Ratio Comparison (APRC) |
|---|---|---|---|
| GS-3 | 8 | $ 48,800 | 1.00 |
| GS-7 | 4 | 32,800 | .80 |
| GS-8 | 3 | 25,200 | .75 |
| GS-13 | 1 | 9,200 | 1.00 |
| GS-21 | 1 | 9,400 | 1.00 |
| GS-27 | 0 | 0 | .00 |
| Grand Totals | 17 | $125,400 | |

| Job Category | Recruitment Needs on Basis of Retirement & Filling Vacancies | Recruitment Needs on Basis of Leaving and Filling Vacancies | Projected Costs With Vacancies Filled | Projected APRC |
|---|---|---|---|---|
| GS-3 | 1 | 2 | $ 48,800 | 1.00 |
| GS-7 | 0 | 1 | 32,800 | .80 |
| GS-8 | 0 | 0 | 25,200 | .75 |
| GS-13 | 0 | 0 | 9,200 | 1.00 |
| GS-21 | 0 | 0 | 9,400 | 1.00 |
| GS-27 | 1 | 1 | 7,800 | 1.00 |
| Grand Totals | 2 | 4 | $133,200 | |

| Job Category | Recruitment Needs on Basis of Retirement, Vacancies, & Additional Personnel | Recruitment Needs on Basis of Leaving, Vacancies & Additional Personnel | Projected Cost | Projected APRC |
|---|---|---|---|---|
| GS-3 | 2 | 3 | $ 56,900 | 1.00 |
| GS-7 | 1 | 2 | 41,000 | 1.00 |
| GS-8 | 1 | 1 | 33,600 | 1.00 |
| GS-13 | 0 | 0 | 9,200 | 1.00 |
| GS-21 | 0 | 0 | 9,400 | 1.00 |
| GS-27 | 1 | 1 | 7,800 | 1.00 |
| Grand Totals | 5 | 7 | $167,900 | |

(Note: Similar output would be generated for the agency, area and BIA. Projections for or future fiscal yrs.would contain the same information.)

In addition to presenting the basic information about the statis personnel situation, the model provides several other types of information, interpretation of which is quite straightforward. Recruitment needs are provided for each job category on the basis of filling vacancies caused by retirement and resignation. Needs based on retirement specify the baseline need, while needs based on resignations indicate a more projective but at the same time more accurate level of recruitment needs. In either case, the projected costs and APRC will be the same.

Finally, projections are made which take the same factors, as well as needs resulting from planned program changes, into consideration. This information is used as the basis for Finance Management Information System budgetary calculations, and the appropriate cost code is therefore included. Again, recruitment needs on the basis of retirement and other factors specify a baseline, while needs on the basis of leaving project a more accurate level of recruitment needs.

Output for the Personnel Projection Model thus provides three types of information: a description of the baseline (present) personnel situation, projected recruitment needs and total budget if present vacancies are filled, and projected recruitment and total budget if present vacancies and new positions are filled. The planner is free to modify recruitment needs and costs in order to meet his budgetary constraints. The planner may also wish to run the model several times with alternaitve school program changes so that he may evaluate the relative costs and benefits of these changes. It should be noted, however, that the Finance Management Information System Model uses the third set of costs as an input. It is therefore important that when the Personnel Projection Model is run to provide this input, estimates of program changes should be realistic as possible.

## INPUTS

The required input for the Personnel Projection Model includes some data readily available to the BIA, other information available as outputs from the Facilities Use and Planning Model, and still other information which will have to be gathered by the BIA. Each input, its characteristics and source are discussed below.

1. $PERSON_2$, $PERSON_3$, and $PERSON_4$ -- These three variables specify respectively the job classification, age and sex of the job-holder for whom information is being read by the model. Such data is presently available by school and is ready by the model according to school.

2. $EXRATE_{K, L}$ -- This input is defined as the rate of leaving BIA schools by age group K and sex, L. Such information will have to be estimated by the BIA, as it is not presently available. Estimation should be made on the basis of survey or sample of persons of all job categories. The leaving rate should be expressed as a percentage of the total number of persons of all job categories. The leaving rate should be expressed as a percentage of the total number of persons in a given age-sex category. In cases where the age group is above mandatory retirement age (see input 4), leaving rate should be specified as 1.00.

3. EXAGE -- This input specifies the mandatory age at which personnel must retire from working in BIA schools.

4. $INRATE_{K, L}$ -- This is the intake analogue of EXRATE. It specifies the percentage of personnel coming into BIA schools who are of an age group K and sex L. Since all incoming personnel must be accounted for in this variable, the sum of INRATE for all K and L cells should equal 1.0. As was the case with EXRATE, this information is not presently available. A random sample of new personnel could be used as the basis for estimating the percentage falling into each cell.

5. $PERBUD_J$--defined as the number of budget positions in each school for job category J, this variable is readily obtainable from the individual BIA schools.

6. Function REQUIRE (J, NSC, $\overrightarrow{NSC}$) -- This function computes the denominator of the actual personnel/requirements ratio by using information about school type, facilities, and enrollment. The specification of the computational basis for the denominator will be different for each job category, since requirements for personnel types will have to take into account different characteristics of the school. The function will use J as an indicator of a formula which computes the denominator using the $\overrightarrow{NSC}$ information for school NSC. Specification of the computation procedure involves the technical implementation of a policy decision by the BIA. The policy decision is one of specifying the basis upon which need for personnel of a certain job category is to be determined. For example, it may be decided that the need for guidance counselors is a function of the number of students in the tenth through twelfth grades, with special weight given to the number of twelfth graders. Such a policy decision might be mathematically specified by the formula:

$$\text{REQUIRE (guidance, NSC, } \overrightarrow{\text{NSC}}\text{)} = \text{No. 10th graders + No. 11th graders + (2X No. of 12th graders).}$$

7. $PERREQ_J$ -- This input states the permitted personnel/requirements ratio, or, in other words, gives a ratio of the maximum number of personnel needed per standard denominator of requirements. Using the same example as that given for Input 6, it might be decided that one guidance counselor is needed for a requirement denominator of 200 (e.g., 50 10th graders, 50 11th graders and 50 12th graders, or 60 10th graders, 60 11th graders, and 40 12th graders). $PERREQ_J$ would then equal 1/200 or .005. As was the case with Input 6, determination of PERREQ is a policy decision to be made by the BIA. Obviously, such a decision is of a less technical nature than that required for Input 6. Furthermore, determination of PERREQ is contingent on specification of REQUIRE, since REQUIRE gives the denominator component of PERREQ.

8. $\overrightarrow{NSC}$ and $\overrightarrow{NAG}$ -- These two vectors provide information about school type, facilities and enrollment. $\overrightarrow{NSC}$ is a vector for each school, while $\overrightarrow{NAG}$ provides information similar to that of $\overrightarrow{NSG}$ for the agency. $\overrightarrow{NAG}$ is provided as an output of the Facilities Use and Planning Model and includes enrollment by grade and detailed information about school facilities in the agency. The $\overrightarrow{NSC}$ information about facilities may also be obtained from the Facilities Use and Planning Model, but information about enrollment by grade in individual schools is not available from this source, and must be obtained from the schools themselves.

The vector for each school might take the following form:

$NSC_1$: school type (0 = day, 1 = boarding)

$NSC_2$ -$NSC_{13}$: flag set to 0 if grade 1 - 12 is not taught; 1 if taught.

$NSC_{14}$-$NSC_{25}$: total enrollment for each grade

$NSC_{26}$: total school enrollment

$NSC_{27}$ -$NSC_N$: number of rooms of a specified type (e. g., regular classrooms; kindergarten rooms; science classrooms, etc.)

Although some of the information included in this vector may not be used in any of the REQUIRE functions, specification of all the information will save a great deal of effort duplication, since the same vector will be used in the Equipment Projection Model.

The $\overrightarrow{NAG}$ vector and $\overrightarrow{NSC}$ vectors should take the same form and format, since the model at one point makes calculations involving both vectors. Obviously $NSC_1$ to $NSC_{13}$ will not be specified for the agency, since it will include all grades and both boarding and day schools. Space equivalent to that used for those variables in the $\overrightarrow{NSC}$ vector should be left blank, and calculations involving both vectors should not include these fields.

9. $DLTAPR_J$ -- This matrix indicates extraordinary changes in personnel due to program changes by job category. For each job category and school, it is thus necessary to specify a positive or negative integer

reflecting such changes. Thus, if the school is going to start a kindergarten program requiring an additional position not presently approved in the budget, such a change should be specified in DLTAPR. The term "extraordinary" should be emphasized, since under most conditions changes in personnel must be budgeted and approved, and thus reflected in $PERBUD_J$. This input information must be provided by the schools themselves.

10. $COST_J$ -- This variable is very simply the dollar salary cost per per per holder of job J. Such information can be easily and quickly provided by the BIA.

11. BLOWUP -- This is a factor used to compute changes in salaries over time. If the average percentage increase for jobs in known, this information can be used. Otherwise, the Consumer Price Index percentage increase provides and adequate basis for estimation.

12. $ICOD_J$ -- The financial cost code for job J. This code is used by the Finance Management Information System as the basis for budget development. The code should thus be specified by the FMIS Model uses.

PROCESS

Although the model process is described in detail in a brief description here will be of interest to the user whose concerns are not strictly of a mathematical or computer programming nature. The model reads the information about personnel for a school and develops a summary matrix for the school. Then, for each job type in the school, the model computes total number of personnel in that job, recruitment needs, the requirements ratio, and costs. When all job types have been evaluated for a particular school, the model prints out the results of calculations and begins to analyze another school in the same manner.

After all schools within an agency have been evaluated and projections made, the model sets up a "new school" for the agency, to project personnel needs for all new facilities not included in presently existing schools. Results are then printed for the agency and the model recycles to another set of schools within another agency. This investing process may be continued untill projections have been made of all schools within an agency, area, or the entire BIA system.

After the desired data has been evaluated for the first or baseline year, input files are changed to reflect changes in personnel, and the model recycles to make projections for further years. In order that projected facilities changes be taken into account in these non-baseline runs, the $\overrightarrow{NAG}$ vector must be included for each year of projection. Changes are not required in any of the other data matrices.

## BIA PERSONNEL PROJECTION MODEL
### Variable List

Input Variables

| | |
|---|---|
| $PERSON_2$ | Job classification of job-holder being read |
| $PERSON_3$ | Age of job-holder |
| $PERSON_4$ | Sex of job-holder |
| $EXRATE_{K,L}$ | Rate of leaving by age, sex |
| EXAGE | Mandatory retirement age |
| $INRATE_{K,L}$ | Rate of entering by age, sex |
| $PERBUD_J$ | Budgeted number of positions for job J |
| Function | $(J, NSC, \overrightarrow{NSC})$ Denominator computation basis for personnel/requirements ratio |
| $PERREQ_J$ | Permitted personnel/requirements ratio |
| $\overrightarrow{NSC}$ and $\overrightarrow{NAG}$ | Vector containing school type, facilities and enrollment information used to compute denominator of personnel/requirements ratio |
| $DLTAPR_J$ | Extraordinary changes in personnel (due to program changes) |
| $COST_J$ | Dollar cost per holder of job J |
| BLOWUP | Consumer Price Index % increase or know wage % increase |
| $ICOD_J$ | Financial cost code for job J |

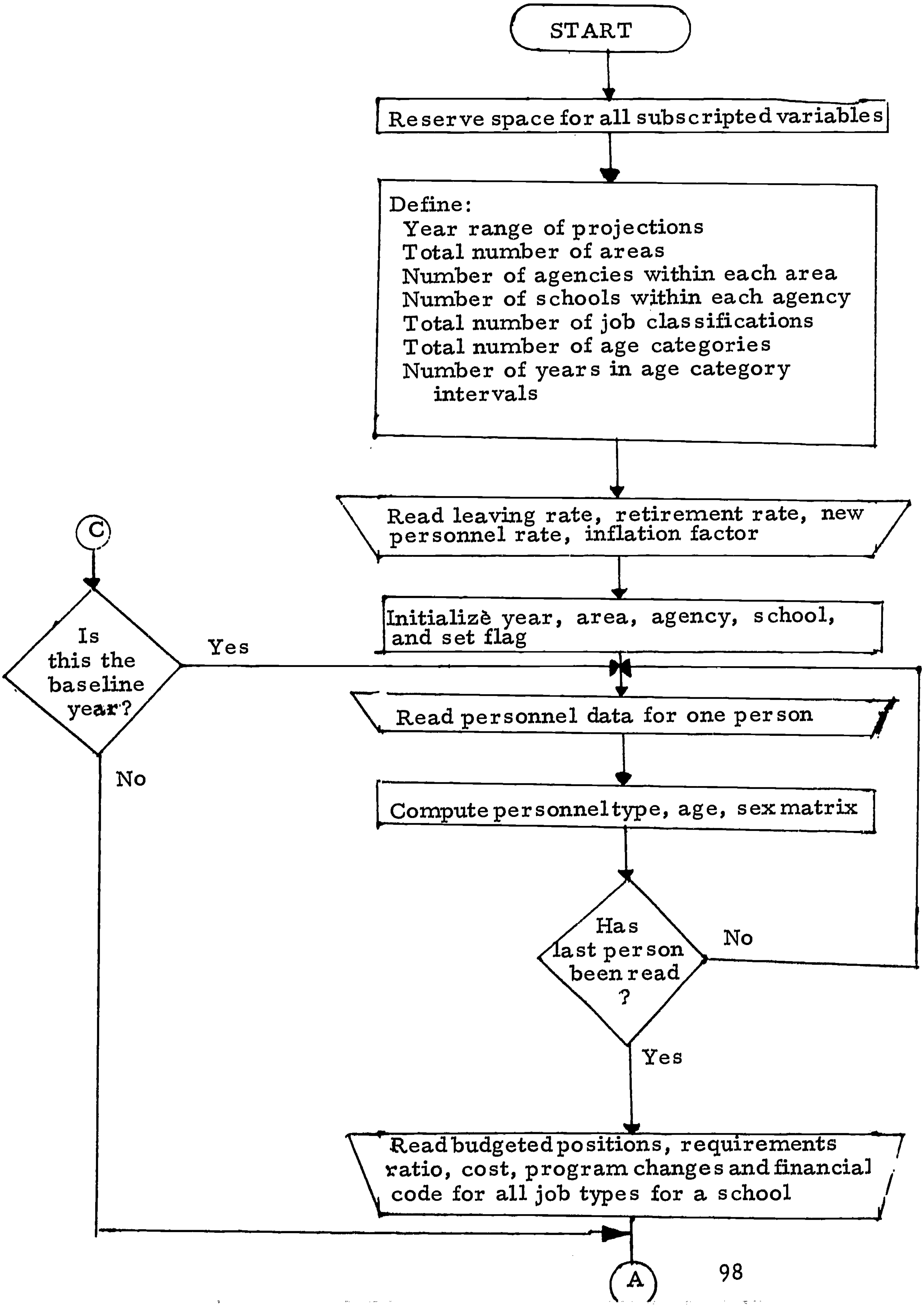
Output Variables - School

| | |
|---|---|
| $PERTOT_J$ | Total personnel for job J |
| $BUDGT_J$ | Present personnel costs |
| $APRC_J$ | Actual-permitted personnel/requirements ratio comparison |
| $VACRE_J$ | Recruitment needs on basis of retirement and unfilled vacancies |
| $VACLE_J$ | Recruitment needs on basis of estimated leaving and unfilled vacancies |
| $BUDGT2_J$ | Projected personnel costs on basis of present personnel and vacancies |

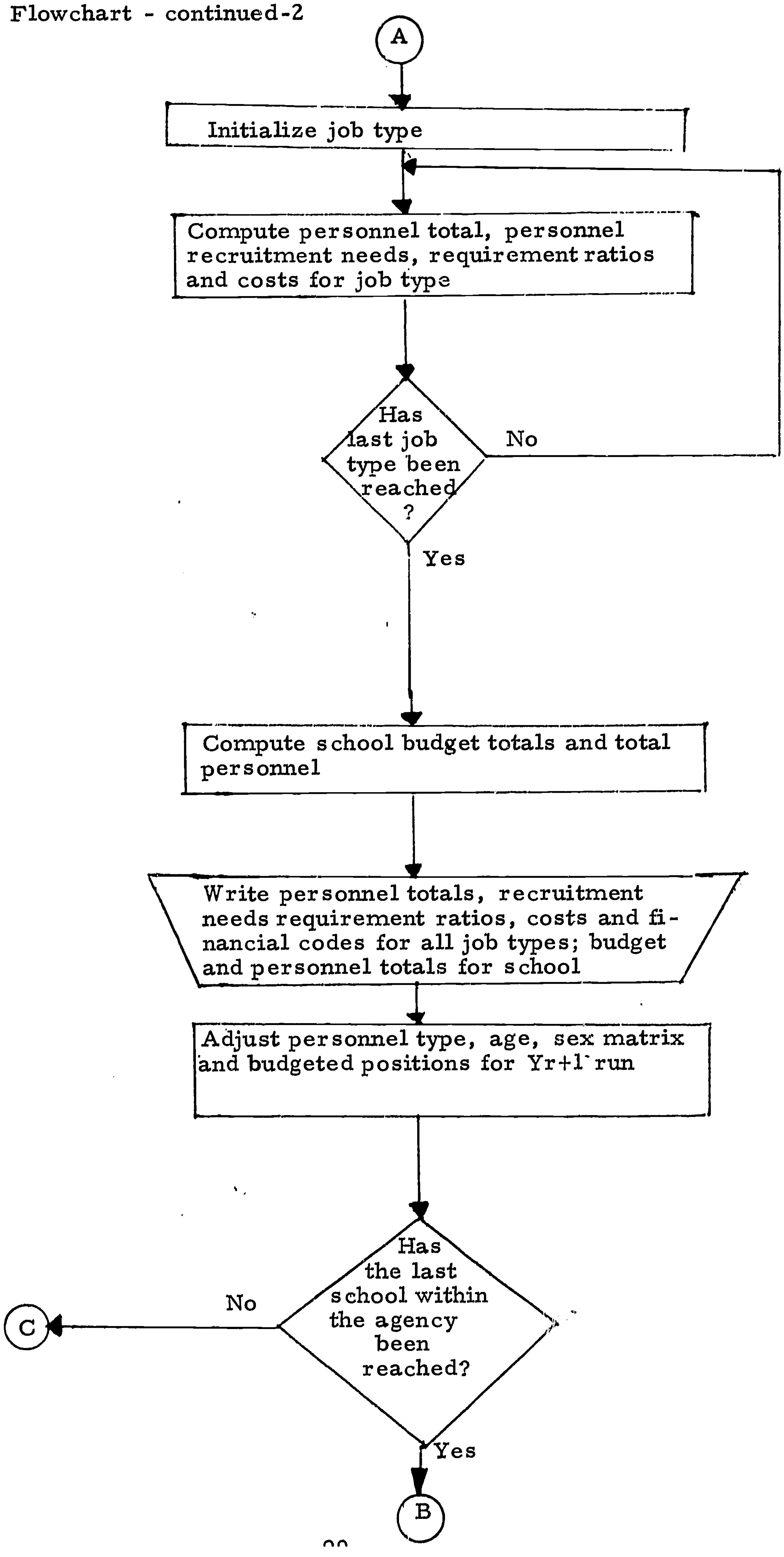
| | |
|---|---|
| $P1APRC_J$ | Projected $APRC_J$ on basis of total personnel and vacancies filled |
| $PERNEW_J$ | Recruitment needs on basis of retirement, vacancies and additional personnel needed |
| $PEREST_J$ | Recruitment needs on basis of leaving, vacancies and additional personnel needed |
| $BUDGT3_J$ | Projected personnel costs on basis of total personnel, vacancies filled, and additional personnel required |
| $P2APRC_J$ | Projected $APRC_J$ on basis of total personnel, vacancies filled, and additional personnel acquired |
| SBUD1, SBUD2, and SBUD3 | Grand total personnel costs for $BUDGT_{1-3}$ |
| STOT | Grand total personnel at present |

BIA PERSONNEL PROJECTION MODEL

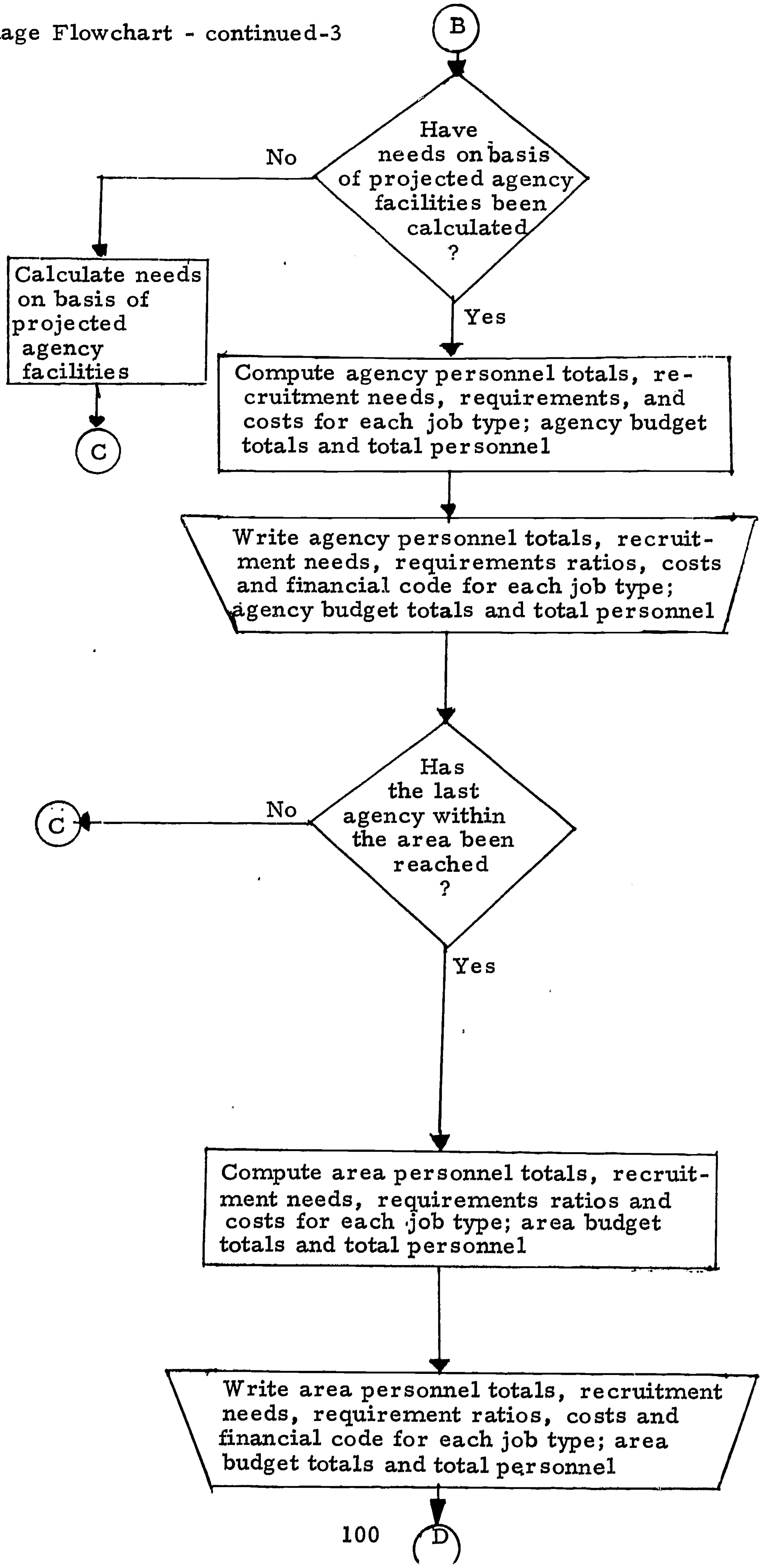
English Language Flowchart



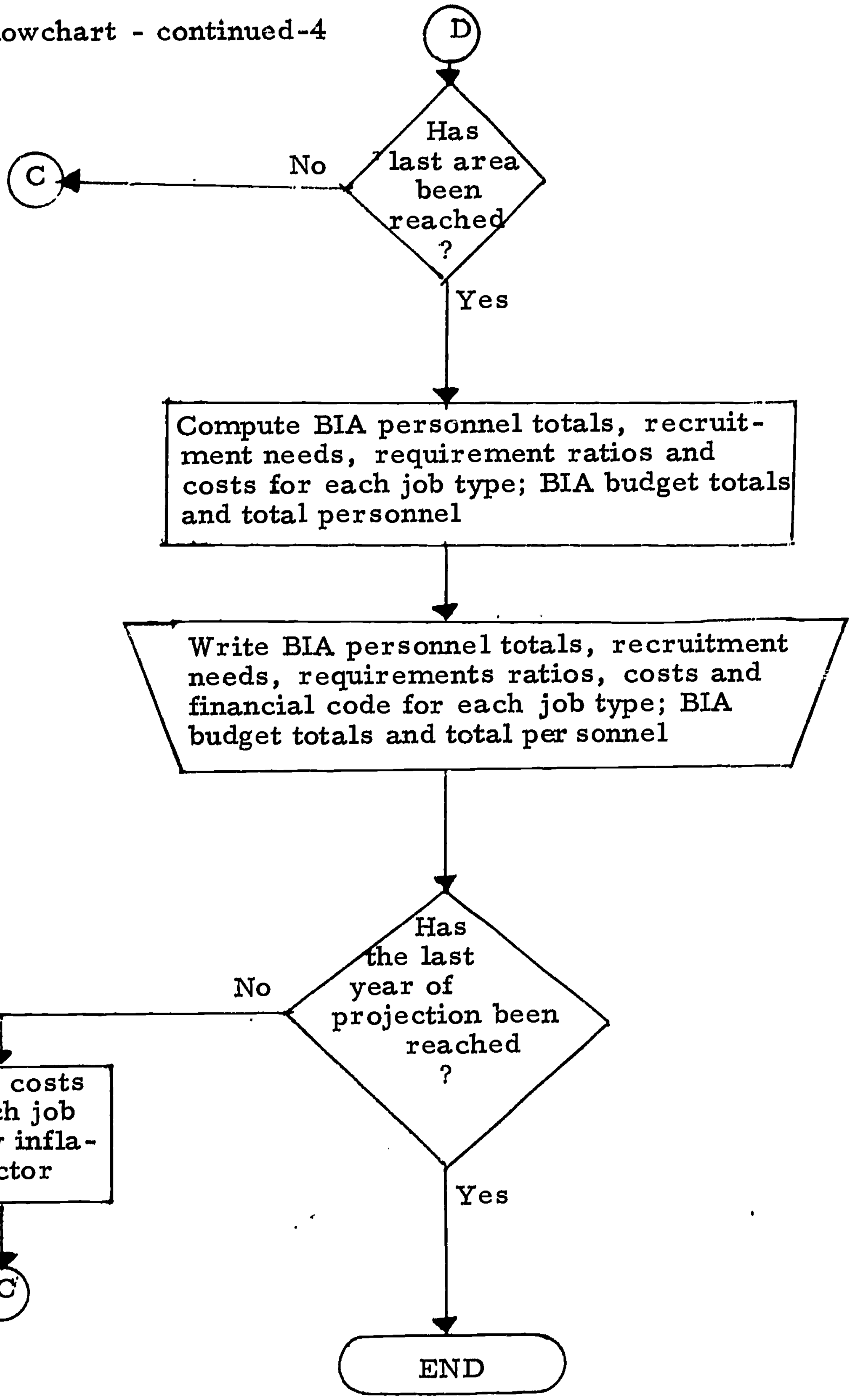
English Language Flowchart - continued-2



English Language Flowchart - continued-3



English Language Flowchart - continued-4



BIA PERSONNEL PROJECTION MODEL

Detailed Mathematical Flowchart

START

Reserve space for all subscripted variables

Define:

NYRTOT - Year range of projection

NARTOT - Total number of areas

$NAGTOT_{NAR}$ - Number of agencies within each area NAR

$NSCTOT_{NHG}$ - Number of schools within each agency NAG

JTOT - Total number of job classifications

KTOT - Total number of age categories

KINT - Number of years in age category intervals

Read $EXRATE_{K, L}$ and $INRATE_{K, L}$ for all K, L; EXAGE and BLOWUP

Initialization:

NYR = 1

NAR = 1

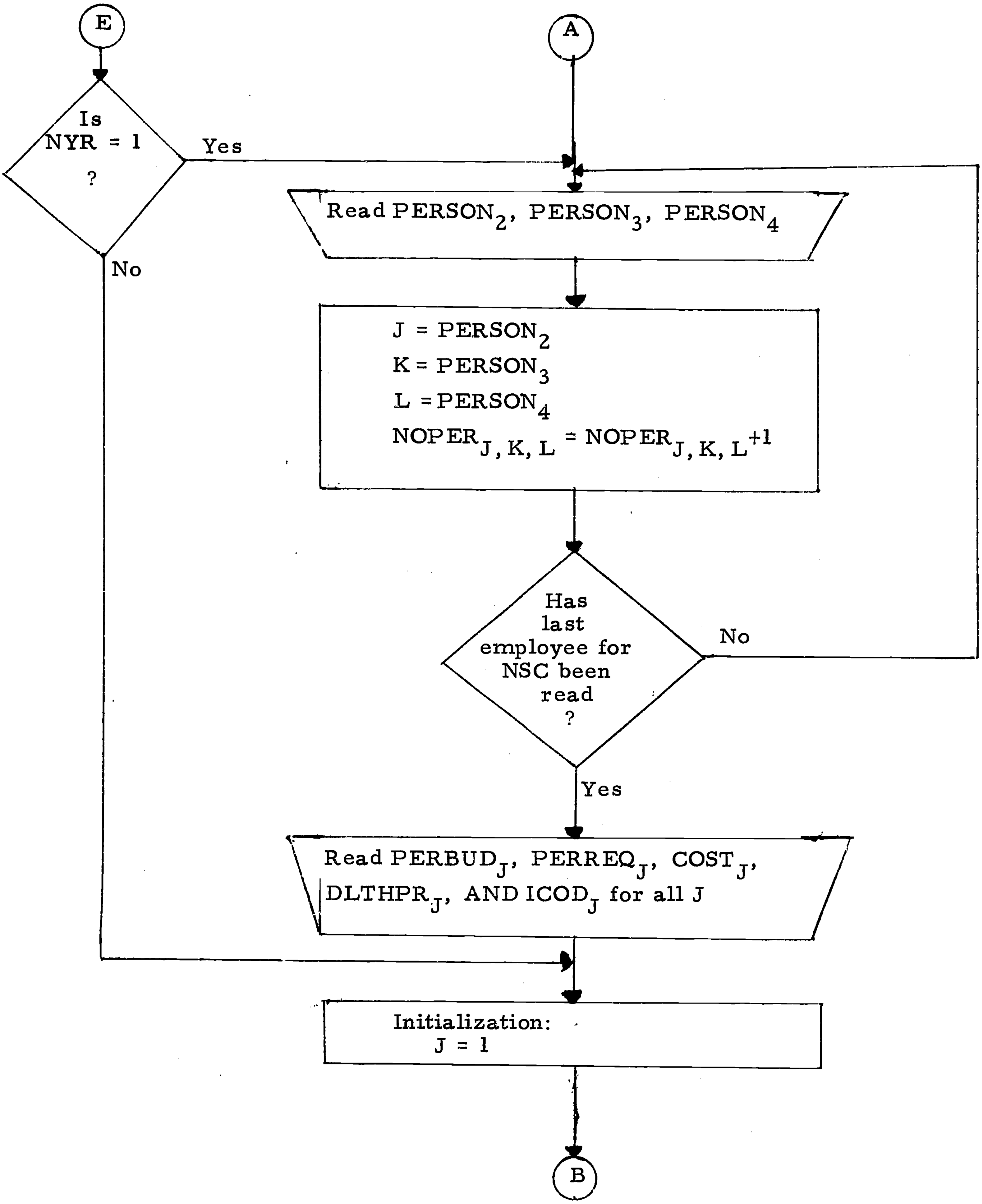
NAG = 1

NSC = 1

IFLAG = 1

A

Detailed Mathematical Flowchart - 2



B

C

$$DEPART_{J,K,L} = NOPGR_{J,K,L} \cdot EXRATE_{J,K,L}$$

$$LEAVE_J = \sum_{K=1}^{KTOT} \sum_{L=1}^{2} DEPART_{J,K,L}$$

$$RETIRE_J = \sum_{K=EXAGE}^{KTOT} NOPER_{J,K,L}$$

$$PERTOT_J = \sum_{K=1}^{KTOT} \sum_{L=1}^{2} NOPER_{J,K,L}$$

$$PERGAR_J = PERBUD_J -- PERTOT_J$$

Call REQUIRE(J, NSC, $\overrightarrow{NSC}$)

$$APEREQ_J = PERTOT_J / REQUIRE(J, NSC, \overrightarrow{NSC})$$

$$APRC_J = APEREQ_J / PERRGQ_J$$

$$VACRE_J = RETIRE_J + PERGAP_J$$

$$VACLE_J = LEAVE_J + PERGAP_J$$

$$PERNEW_J = RETIRE_J + PERGAP_J + DLTAPR_J$$

$$PEREST_J = LEAVE_J + PERGAP_J + DLTAPR_J$$

$$P1APRC_J = ((PERTOT_J + PERGAP_J) / REQUIRE(J, NSC, \overrightarrow{NSC})) / PERREQ_J$$

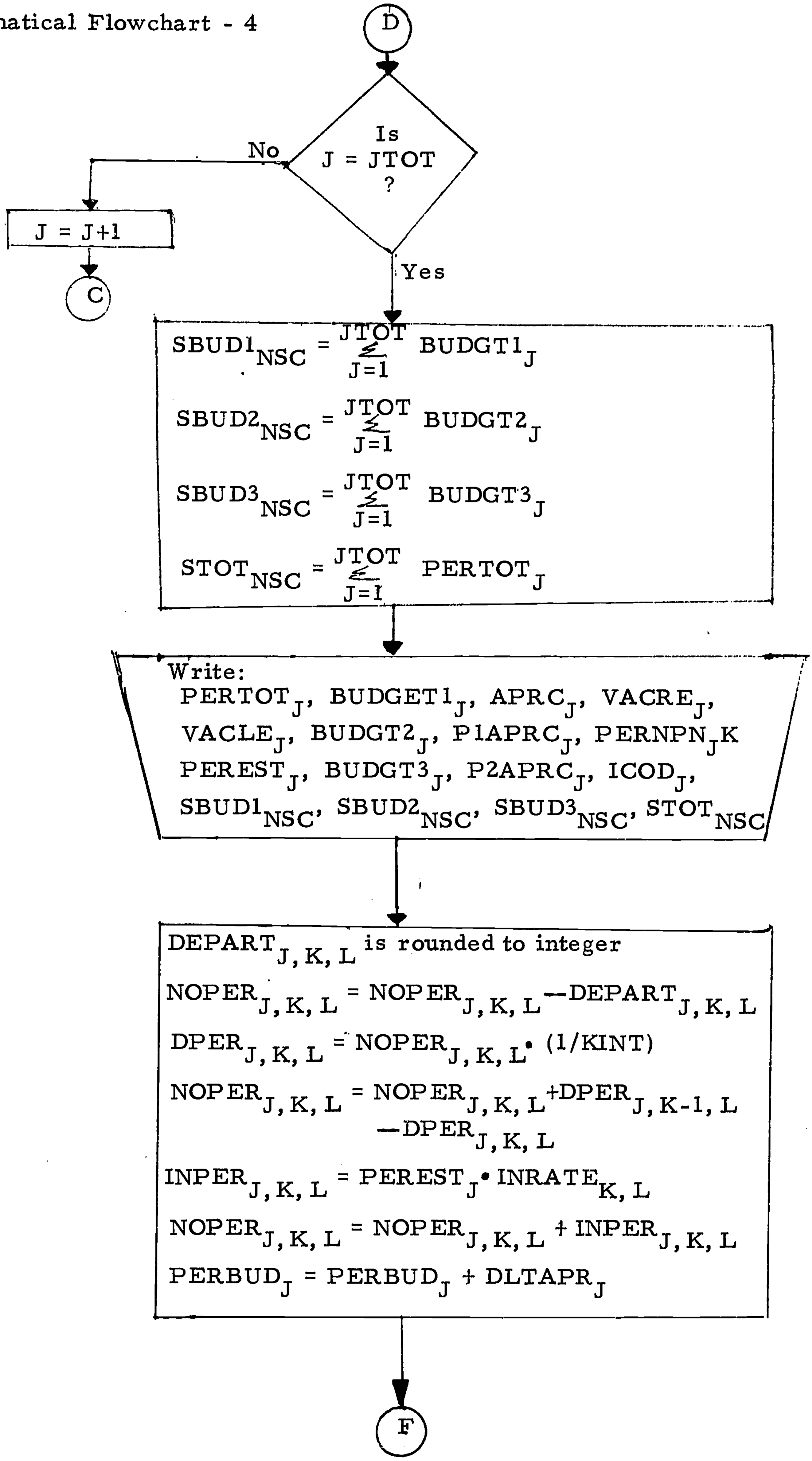
$$BUDGT1_J = PERTOT_J \cdot COST_J$$

$$BUDGT2_J = (PERTOT_J + PERGAP_J) \cdot COST_J$$

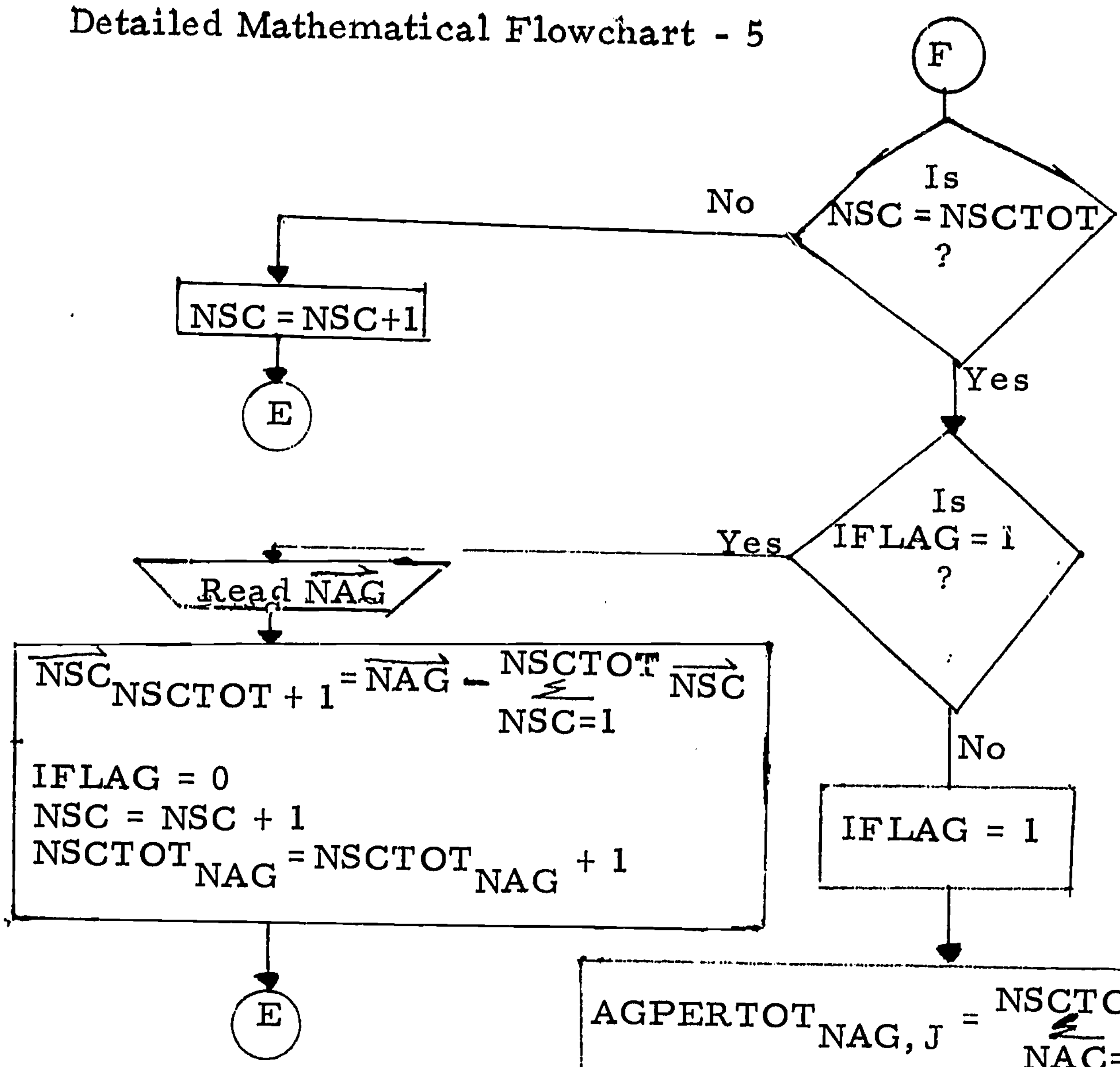
$$BUDGT3_J = (PERTOT_J + PERGAP_J + DLTAPR_J) \cdot COST_J$$

D

Detailed Mathematical Flowchart - 4



Detailed Mathematical Flowchart - 5




$$AGPERTOT_{NAG,J} = \sum_{NAC=1}^{NSCTOT} PERTOT_{NSC,J}$$

$$AGBUDGT1_{NAG,J} = \sum_{NSC=1}^{NSCTOT} BUDGT1_{NSC,J}$$

$$AGVACRE_{NAG,J} = \sum_{NSC=1}^{NSCTOT} PERTOT_{NSC,J}$$

$$AGVACLE_{NAG,J} = \sum_{NSC=1}^{NSCTOT} VACLE_{NSC,J}$$

$$AGBUDGT2_{NAG,J} = \sum_{NSC=1}^{NSCTOT} BUDGT2_{NSC,J}$$

$$AGPERNEW_{NAG,J} = \sum_{NSC=1}^{NSCTOT} PERNEW_{NSC,J}$$

$$AGPEREST_{NAG,J} = \sum_{NSC=1}^{NSCTOT} PEREST_{NSC,J}$$

$$AGBUDGT3_{NAG,J} = \sum_{NSC=1}^{NSCTOT} BUDGT3_{NSC,J}$$

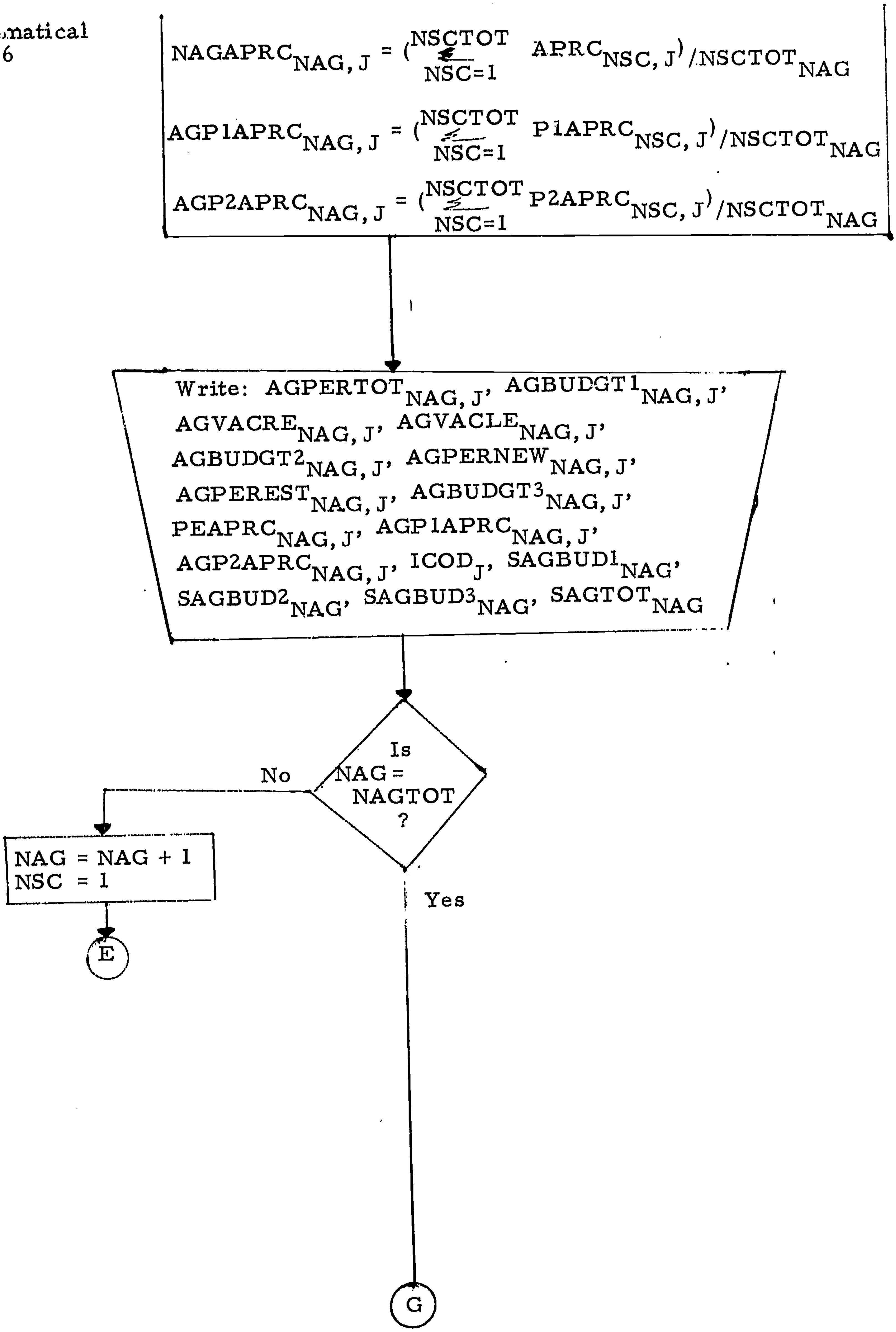
$$SAGBUD1_{NAG} = \sum_{NSC=1}^{NSCTOT} SBUD1_{NSC}$$

$$SAGBUD2_{NAG} = \sum_{NSC=1}^{NSCTOT} SBUD2_{NSC}$$

$$SAGBUD3_{NAG} = \sum_{NSC=1}^{NSCTOT} SBUD3_{NSC}$$

$$SAGTOT_{NAG} = \sum_{NSC=1}^{NSCTOT} STOT_{NSC}$$

(continued)


$NAGAPRC_{NAG,J} = (\sum_{NSC=1}^{NSCTOT} APRC_{NSC,J})/NSCTOT_{NAG}$
$AGP1APRC_{NAG,J} = (\sum_{NSC=1}^{NSCTOT} P1APRC_{NSC,J})/NSCTOT_{NAG}$
$AGP2APRC_{NAG,J} = (\sum_{NSC=1}^{NSCTOT} P2APRC_{NSC,J})/NSCTOT_{NAG}$
Write: $AGPERTOT_{NAG,J}$, $AGBUDGT1_{NAG,J}$, $AGVACRE_{NAG,J}$, $AGVACLE_{NAG,J}$, $AGBUDGT2_{NAG,J}$, $AGPERNEW_{NAG,J}$, $AGPEREST_{NAG,J}$, $AGBUDGT3_{NAG,J}$, $PEAPRC_{NAG,J}$, $AGP1APRC_{NAG,J}$, $AGP2APRC_{NAG,J}$, $ICOD_J$, $SAGBUD1_{NAG}$, $SAGBUD2_{NAG}$, $SAGBUD3_{NAG}$, $SAGTOT_{NAG}$
Is NAG = NAGTOT ?
No
Yes
NAG = NAG + 1
NSC = 1
E
G

G

$$
\left.\begin{aligned}
&ARPERTOT_{NAR,J} =\\
&ARBUDGT1_{NAR,J} =\\
&ARVACRE_{NAR,J} =\\
&ARVACLE_{NAR,J} =\\
&ARBUDGT2_{NAR,J} =\\
&ARPERNEW_{NAR,J} =\\
&ARPEREST_{NAR,J} =\\
&ARBUDGT3_{NAR,J} =\\
&SARBUD1_{NAR} =\\
&SARBUD2_{NAR} =\\
&SARBUD3_{NAR} =\\
&SARTOT_{NAR} =
\end{aligned}\right\} \sum_{NAG=1}^{NAGTOT} \left\{\begin{aligned}
&AGPERTOT_{NAG,J}\\
&AGBUDGT1_{NAG,J}\\
&AGVACRE_{NAG,J}\\
&AGVACLE_{NAG,J}\\
&AGBUDGT2_{NAG,J}\\
&AGPERNEW_{NAG,J}\\
&AGPEREST_{NAG,J}\\
&AGBUDGT3_{NAG,J}\\
&SAGBUD1_{NAG}\\
&SAGBUD2_{NAG}\\
&SAGBUD3_{NAG}\\
&SARTOT_{NAG}
\end{aligned}\right.
$$

$$ARAPRC_{NAR,J} = \left(\sum_{NAG=1}^{NAGTOT} AGAPRC_{NAG,J}\right)/NAGTOT_{NAR}$$

$$ARP1APRC_{NAR,J} = \left(\sum_{NAG=1}^{NAGTOT} AGP1APRC_{NAG,J}\right)/NAGTOT_{NAR}$$

$$ARP2APRC_{NAR,J} = \sum_{NAG=1}^{NAGTOT} AGP2APRC_{NAG,J})/NAGTOT_{NAR}$$

Write: $ARPERTOT_{NAR,J}$, $ARBUDGT1_{NAR,J}$, $ARVACRE_{NAR,J}$, $ARVACLE_{NAR,J}$, $ARBUDGT2_{NAR,J}$, $ARPERNEW_{NAR,J}$, $ARPEREST_{NAR,J}$, $ARBUDGT3_{NAR,J}$, $SARBUD1_{NAR}$, $SARBUD2_{NAR}$, $SARBUD3_{NAR}$, $SARTOT_{NAR}$, $ARAPRC_{NAR,J}$, $ARP1APRC_{NAR,J}$, $ARP2APRC_{NAR,J}$ -$ICOD_J$

Is NAR = NARTOT ?

No

NAR = NAR + 1
NAG = 1
NSC = 1

E

Yes

H

(H)

$$BPERTOT_{NAR,J} = \sum_{NAG=1}^{NAGTOT} ARPERTOT_{NAG,J}$$
$$BBUDGT1_{NAR,J} = \sum_{NAG=1}^{NAGTOT} ARBUDGT1_{NAG,J}$$
$$BVACRE_{NAR,J} = \sum_{NAG=1}^{NAGTOT} ARVACRE_{NAG,J}$$
$$BVACLE_{NAR,J} = \sum_{NAG=1}^{NAGTOT} ARVACLE_{NAG,J}$$
$$BBUDGT2_{NAR,J} = \sum_{NAG=1}^{NAGTOT} ARBUDGT2_{NAG,J}$$
$$BPERNEW_{NAR,J} = \sum_{NAG=1}^{NAGTOT} ARPERNEW_{NAG,J}$$
$$BPEREST_{NAR,J} = \sum_{NAG=1}^{NAGTOT} ARPEREST_{NAG,J}$$
$$BBUDGT3_{NAR,J} = \sum_{NAG=1}^{NAGTOT} ARBUDGT3_{NAG,J}$$
$$SBBUD1_{NAR} = \sum_{NAG=1}^{NAGTOT} SARBUD1_{NAG}$$
$$SBBUD2_{NAR} = \sum_{NAG=1}^{NAGTOT} SARBUD2_{NAG}$$
$$SBBUD3_{NAR} = \sum_{NAG=1}^{NAGTOT} SARBUD3_{NAG}$$
$$SBTOT_{NAR} = \sum_{NAG=1}^{NAGTOT} SARTOT_{NAG}$$

$$BAPRC_{NAR,J} = \left(\sum_{NAG=1}^{NAGTOT} ARAPRC_{NAG,J}\right)/NAGTOT_{NAR}$$

$$BP1APRC_{NAR,J} = \left(\sum_{NAG=1}^{NAGTOT} ARP1APRC_{NAG,J}\right)/NAGTOT_{NAR}$$

$$BP2APRC_{NAR,J} = \left(\sum_{NAG=1}^{NAGTOT} ARP2APRC_{NAG,J}\right)/NAGTOT_{NAR}$$

↓

Write: $BPERTOT_{NAR,J}$, $BBUDGT1_{NAR,J}$, $BVACRE_{NAR,J}$, $BVACLE_{NAR,J}$, $BBUDGT2_{NAR,J}$, $BPERNEW_{NAR,J}$, $BPEREST_{NAR,J}$, $BBUDGT3_{NAR,J}$, $SBBUD1_{NAR}$, $SBBUD2_{NAR}$, $SBBUD3_{NAR}$, $SBTOT_{NAR}$, $BAPRC_{NAR,J}$, $BP1APRC_{NAR,J}$, $BP2APRC_{NAR,J}$ $-ICOD_J$

↓

Is NYR = NYRTOT ?

No →

$COST_J = COST_J\ (1 + BLOWU$

for all J

NYR = NYR + 1

NAR = 1

NAG = 1

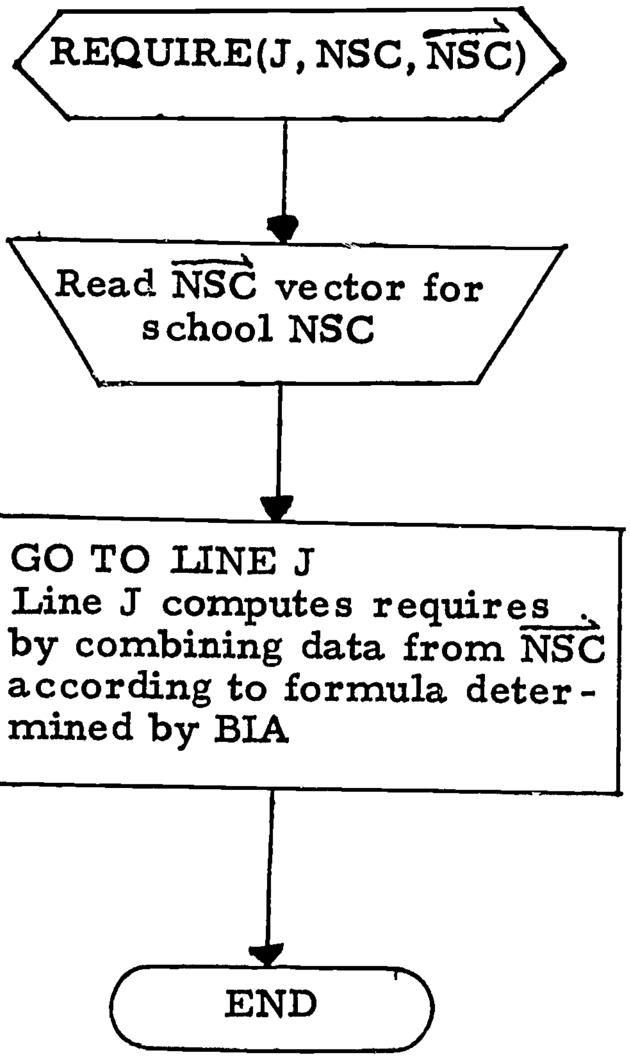
NSC = 1

→ (E)

Yes →

END

Detailed Mathematical Flowchart - 9



## Chapter VII

## Equipment Projection Model

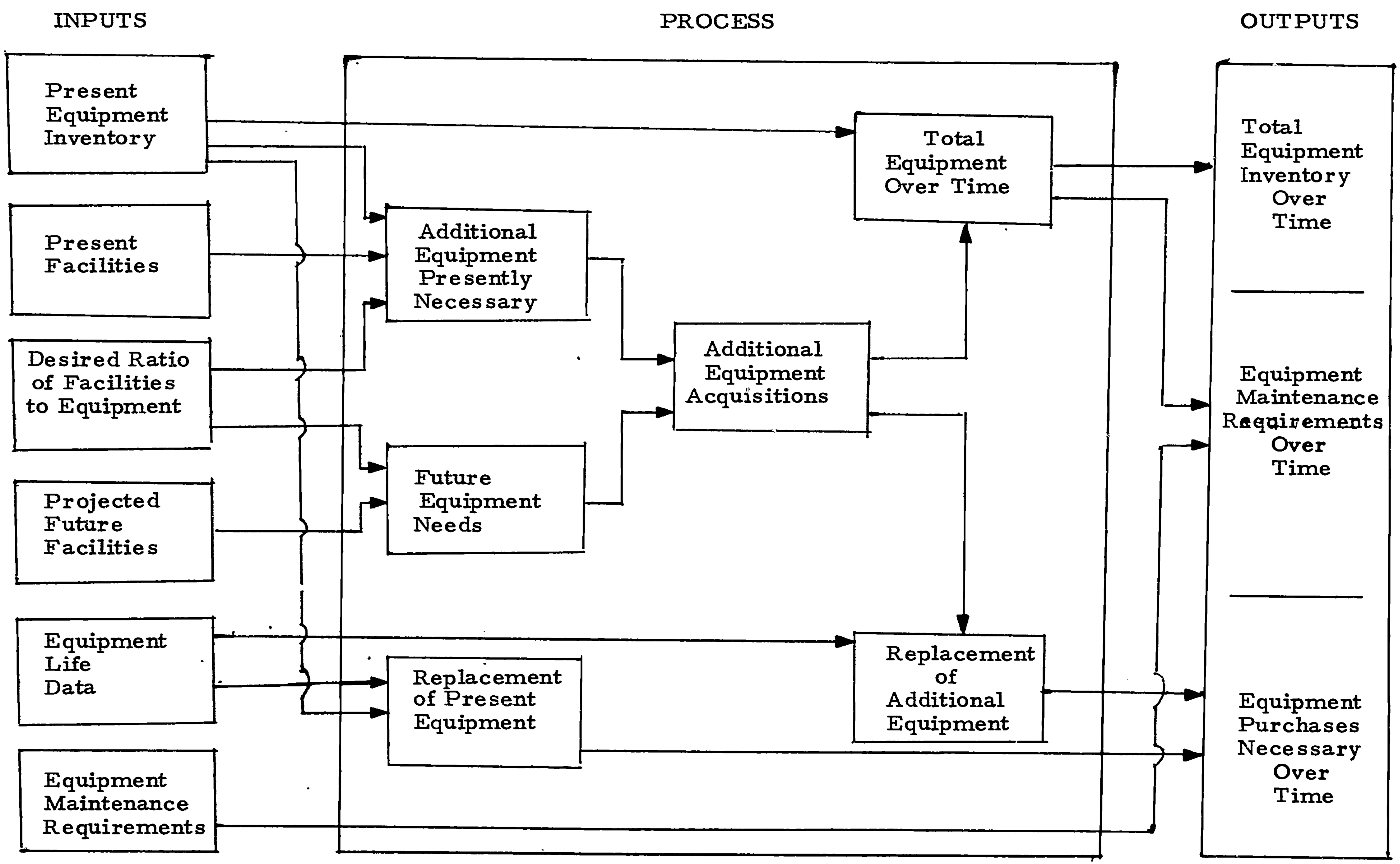
### DESCRIPTION OF OBJECTIVES

As the BIA schools increase the number of their employees and improve their facilities, new equipment will be required. The objective of this model is to project these needs and their costs, so that equipment procurement may be accomplished more effectively and so that future budgeting may be as accurate as possible.

The model will require the following inputs: equipment needs, by such various indicator variables as type of school, grades taught, facilities, and enrollment; desired ratios; present equipment inventory; and maintenance requirements. Changes in these data will be used to give output projections of inventories, necessary purchases and maintenance requirements, as well as of their costs. The model is designed so that it may be used with any number of schools, agencies and areas for which data is available.

A conceptual flowchart of the model appears on the next page. It is followed by a description of the required inputs and their sources, the model's outputs and their interpretation; and the process by which the model determines the outputs from inputs. A variable list, and detailed English Language and Mathematical Flowcharts for the model are included in Appendix E.

## BIA EQUIPMENT PROJECTION MODEL



## OUTPUTS

The Equipment Projection Model provides specific output information for each school, as well as summary information for each agency and area and for the entire BIA. Since the most detailed information is that for each school, the following discussion will be limited to output on that level; interpretation of the other types of output follows the same lines as that for schools.

As will be noted in the sample output which appears below, output information for the school is of two general types. The first is a summary of categories of equipment; the second, detailed information on the specific articles within each category.

The first type of output, for broad categories of equipment, such as science equipment, audio-visual equipment, and dormitory furniture, lists for each category: the total number of items of that category processed by the school; the maintenance costs; the number of items to be replaced or purchased; the purchase costs; and the ratio of equipment for facilities (EFDEF).

The EFDEF ratio is a measure of the degree to which the desired ratio of equipment to facilities is fulfilled by the present inventory of equipment. For example, in the category of dormitory furniture it is desired that one bed be provided for each enrolled student (DEF = 1.0). If at a particular boarding school there are 100 students and 98 beds, EFDEF = .98. When the EFDEF ratio is less than 1.0, the model calculates the number of purchases required to reach the desired ratio.

EQUIPMENT PROJECTION MODEL: SAMPLE OUTPUT

SCHOOL: Mesa Verde Boarding School

1. Summary for Categories of Equipment

| Category | No. of Items | Maintenance Cost | No. of Items to be Replaced or Purchased | Purchase and Replacement Cost |
|---|---|---|---|---|
| Science Equip. | 27 | $42.00 | 2 | $210.00 |
| Dorm. Furniture | 10 | 0.00 | 1 | 110.00 |
| Sports Equip. | 18 | 0.00 | 3 | 157.00 |
| A.V. Equip. | 6 | 28.00 | 1 | 108.53 |
| Totals | | $70.00 | | $585.53 |

EFDEF Ratio

.91
.86
.95
.86

2. Item Inventory Within Category

Category: A.V. Equipment

| Item | Age in Years 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8+ | Total |
|---|---|---|---|---|---|---|---|---|---|
| Projector | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |
| Slide Projector | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| Film Strip Proj. | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Tape Recorder | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |

3. Item Maintenance Within Category

Category: A.V. Equipment

| Item | Cost of Maintenance |
|---|---|
| Projector | $18.00 |
| Slide Projector | 2.00 |
| Film Strip Proj. | 1.00 |
| Tape Recorder | 7.00 |
| Total | $28.00 |

4. Item Replacement Within Category

| Category: A. V. Equip. | Inventory | Replacements Needed | E/F/ /DE/F | DE/F | Purchases Necessary to Reach Desired Ratio |
|---|---|---|---|---|---|
| Projector | 2 | 0 | 1.00 | 2/150 | 0 |
| Slide Projector | 2 | 0 | 1.00 | 2/150 | 0 |
| Film Strip Proj. | 1 | 0 | 1.00 | 1/150 | 0 |
| Tape Recorder | 1 | 0 | .50 | 2/150 | 1 |

| Number of Years Allowed to Reach Desired Ratio | Number of Purchases This Year | Cost |
|---|---|---|
| - | - | - |
| - | - | - |
| - | - | - |
| 1 | | $108.53 |

AGENCY: Fort Apache - Fiscal Year 1969-1970

1. Summary for Categories of Equipment

| Category | No. of Items | No. of Items to be Maintained | Maintenance Cost | No. of Items to be Replaced | Replacement Cost |
|---|---|---|---|---|---|
| Science Equip. | 87 | 18 | $187.00 | 7 | $896.00 |
| Dorm. Furn. | 52 | 3 | 26.00 | 4 | 486.00 |
| Sports Equip. | 76 | 2 | 8.00 | 3 | 157.00 |
| A.V. Equip. | 37 | 37 | 156.00 | 5 | 782.00 |
| Totals | | | $377.00 | | $2,321.00 |

| E/F//DE/F | DE/F |
|---|---|
| .88 | 1/35 |
| .87 | 1/13 |
| .92 | 1/18 |
| .79 | 1/12 |

2. Summary for Schools

Equipment Category: A.V. Equipment

| School | No. of Items | No. of Items to be Maintained | Maintenance Cost | No. of Items to be Replaced | Replacement Cost |
|---|---|---|---|---|---|
| Mesa Verde | 6 | 6 | $ 28.00 | 1 | $108.53 |
| San Jose | 8 | 8 | 37.50 | 2 | 256.00 |
| Central | 7 | 7 | 34.00 | 1 | 108.53 |
| Tewa | 4 | 4 | 22.75 | 0 | 0.00 |
| Manual | 5 | 5 | 27.50 | 1 | 127.80 |
| Totals | | | $149.75 | | $600.86 |

| E/F//DE/F | DE/F |
|---|---|
| .86 | 1/10 |
| .72 | 1/10 |
| .92 | 1/11 |
| .71 | 1/8 |

3. Summary of Maintenance and Purchase Costs for Schools

| School | Maintenance Costs | Replacement Costs |
|---|---|---|
| Tewa | $973.00 | $1,478.07 |

AREA: Arizona - Fiscal Year 1969-1970

1. Summary for Categories of Equipment

| Category | No. of Items | No. of Items to be Maintained | Maintenance Cost | No. of Items to be Replaced | Replacement Cost |
|---|---|---|---|---|---|
| Dorm. Furn. | 83 | 4 | $37.40 | 11 | $834.72 |

| E/F//FE/F | DE/F |
|---|---|
| .92 | 1/13 |

2. Summary for Agencies

Equipment Category: A. V. Equipment

| Agency | No. of Items | No. of Items to be Maintained | Maintenance Cost | No. of Items to be Replaced | Replacement Cost |
|---|---|---|---|---|---|
| Fort Apache | 37 | 37 | $156.00 | 5 | $782.00 |

| E/F//DE/F | DE/F |
|---|---|
| .79 | 1/12 |

3. Summary of Maintenance and Purchase Costs for Agencies

| Agency | Maintenance Costs | Replacement Costs |
|---|---|---|
| Fort Apache | $8,642.81 | $10,298.00 |

The second type of output provides detailed information about items within the categories listed in the first section of output. A matrix of the number of articles by their age and a second matrix of the total number of pieces of equipment are provided for each equipment item. Maintenance costs are listed by item. Finally, a detailed breakdown of the logic of purchasing is provided for each item. This breakdown includes present inventory, number of replacements needed, EFDEF ratio, the desired equipment/facilities (DEF) ratio, the number of purchases necessary to reach the desired EFDEF ratio of 1.0, the number of years allowed to reach the desired ratio, and finally the number of purchases and associated costs for the year. The number of years allowed to reach the ratio is an input by which the user can specify the urgency of fulfilling the EFDEF ratio. In the example of dormitory beds, it is important that a ratio of 1.0 be achieved each year; the urgency of the desired ratio for such other types of equipment as microscopes is less.

The output of the model at the agency, area, and BIA levels summarizes data for categories of equipment and for each school (agency, area) with all categories combined. It is thus possible to analyze the allocation of equipment resources along both these dimensions.

The output of the model takes the same form for both baseline and projected years. The baseline output gives the actual inventory and needs; the projection year outputs are based on the assumption that the purchase and replacement decisions dictated by the model in previous years have been implemented.

INPUTS

The model requires a variety of inputs, all of which are readily available to the Bureau. Some inputs can be derived from records presently maintained; others are provided as outputs of the present series of models. Still others require explicit policy decisions by the BIA. The characteristics and probable source of each input are discussed below.

1. $ITEMAGE_{I,J}$ - This variable describes the age in years from date of purchase of each existing piece of equipment of category I and item

type J. The model reads this input for each piece of equipment in a school and then computes a matrix of school's inventory from it. The information required should be available from the individual school's records.

2. $\text{MAINTCOST}_{I,J}$ - The mean cost of maintenance per year for an item I, J. This data is to be estimated by the Bureau, presumably on the basis of a survey of maintenance costs for individual items in a sample of schools. It is also possible for the Bureau to effect changes in the quality of maintenance by allocating more or less money to the maintenance of equipment.

3. FUNCTION FACIL (I, J, NSC, NSC) - This function is used in computing the denominator of the Equipment/Facilities ratio. For each separate equipment item, it specifies how data from the vector NSC is to be combined to provide an index of the magnitude of characteristics which generate a need for the particular item of equipment. I and J are the basis for using a formula of combination which is a technical specification requiring a BIA policy decision. It may be decided, for example, that teacher desks should be provided on the basis of the number of classrooms and administration rooms in a school. This decision is then implemented by specification of the formula such that:

FACIL (teacher desks, NSC, NSC) = sum of all classroom types and number of administrative rooms

4. $\overrightarrow{NSC}$ - This is a vector of school facilities and enrollments, and $\overrightarrow{NAG}$ is a vector of total agency facilities and enrollments. $\overrightarrow{NAG}$ is an output of the Facilities Use and Planning Model; $\overrightarrow{NSC}$ must be determined for each school for the baseline year. Both vectors are used as they were in the Personnel Projection Model (Section 4.2.5) and are described in detail in that section.

5. $\text{DEF}_{I,J}$ - The desired equipment/facilities ratio for each equipment item is a figure to be set by a policy decision of the BIA, using the computational basis for FACIL as the denominator. Thus, in the example used in input 4 above, one desk might be desired for each

class or administrative room, in which case $DEF_{I,J}$ (teacher desks) would equal 1.0.

6. $EQUIPLIFE_{I,J}$ - This is the mean replacement age of an equipment item -- that is, how many years from date of purchase an average piece of equipment of a particular type may be expected to last. This information may be obtained by a survey of sample schools or may be estimated.

7. $DESBYKR_{I,J}$ - This input is defined for each equipment item as the number of years available to reach the desired ration $DEF_{I,J}$. It is an estimate of the degree of urgency in reaching desired ratios. Thus, though such items as beds and desks will have a DESBYYR of 1, other items, such as microscopes or film projections, are long-term investments and can be purchased over the course of several years.

8. $PRICE_{I,J}$ - The cost for purchase of a new item of type I, J. This information is readily obtainable by checking price lists for equipment purchased by BIA schools.

9. BLOWUP - The rate of increase in prices of equipment, probably best estimated by the wholesale price index percentage increase for the past twelve months.

10. ICOD - The financial cost code for equipment, to be included in output when that output is used by the Finance Management Information System Model.

PROCESS

The model's outputs are determined by schools within an agency, agencies within an area, and areas within the BIA. The model constructs for each school both a total inventory and an inventory by age matrix, by reading information for present items of equipment. Maintenance costs are computed by multiplying the number of items by cost for that type of item. The EFDEF ratio is calculated and used as a basis for determining the number of purchases necessary to reach a desired ratio. The number of purchases is then divided by the number of years to reach a desired ratio. The result, combined with the number of replacements necessary because of equipment depreciation, gives the total number of purchases necessary for the present year. The cost is then calculated, and the inventory matrix is adjusted to take into account purchases and replacements. After this sequence has been accomplished for all equipment items within a school, the model recycles to evaluate the same data for another school. When evaluations for all schools within an agency have been made, the model calculates the difference between present school facilities and projected agency facilities for the year. The difference is treated as one school for whcih equipment needs are then calculated.

The model then prints summary information for the agency and begins calculations for schools in another agency. This sequence may be continued for as many schools, agencies, and areas as desired. After calculations for the baseline year have been made, the model recycles and calculates outputs with the changed inventory matrices for each school, and with changed facilities vectors.

## BIA EQUIPMENT PROJECTION MODEL

### Variable List

Input Variables

| | |
|---|---|
| $ITEMAGE_{I,J}$ | Age of equipment item in category I, with name J |
| $MAINTCOST_{I,J}$ | Mean cost of maintenance for item I, J |
| Function $FACIL(I, J, NSC, \overrightarrow{NSC})$ | Function combining school data and enrollment to provide estimate of facilities and school characteristics germane to particular equipment item |
| $\overrightarrow{NSC}$ | Vector containing school facilities and characteristics data for a year |
| $\overrightarrow{NAG}$ | Vector containing projected total agency facilities and characteristics for a year |
| $DEF_{I,J}$ | Desired equipment/facilities ratio defined by WO, area, or agency |
| $EQUIPLIFE_{I,J}$ | Mean replacement age of item |
| $DESBYYR_{I,J}$ | Number of years to reach desired ratio for item |
| $PRICE_{I,J}$ | Cost of item |
| BLOWUP | Wholesale price index % increase in one year |
| ICOD | Financial cost code of equipment |

Output Variables

| | |
|---|---|
| $ITIN_{I,J}$ | Inventory for item |
| $ITMAINT_{I,J}$ | Maintenance costs for inventory of item |
| $PURYR_{I,J}$ | Number of purchases of item for year |
| $COST_{I,J}$ | Cost of purchases of item for year |
| $EFDEF_{I,J}$ | Equipment/facilities - desired equipment/facilities ratio for item |

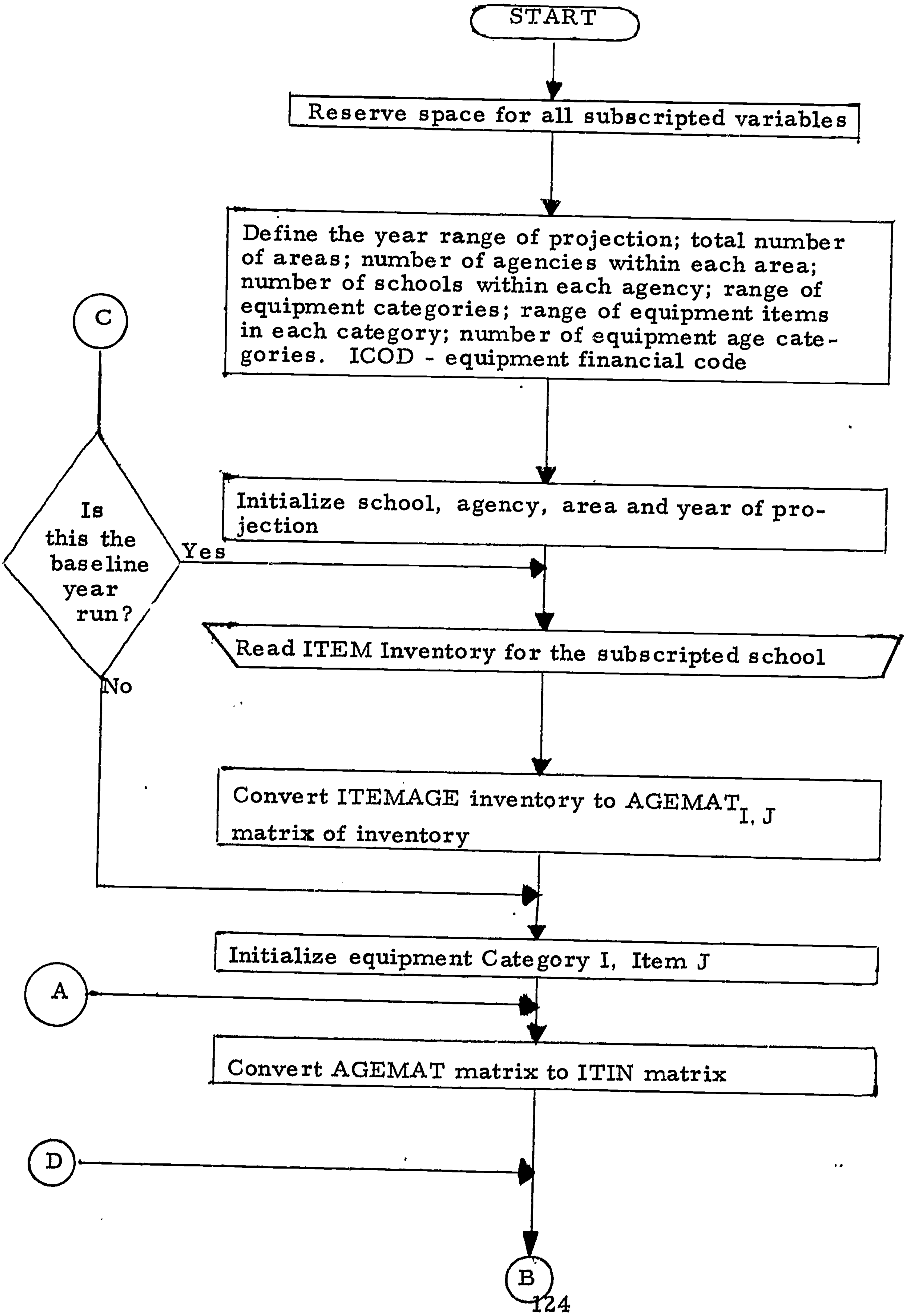
$$\left.\begin{array}{l} SITIN_I \\ SITMAINT_I \\ SPURYR_I \\ SCOST_I \\ SEFDEF_I \end{array}\right\} \text{Summary of output for category I}$$

Output Variables (cont.)

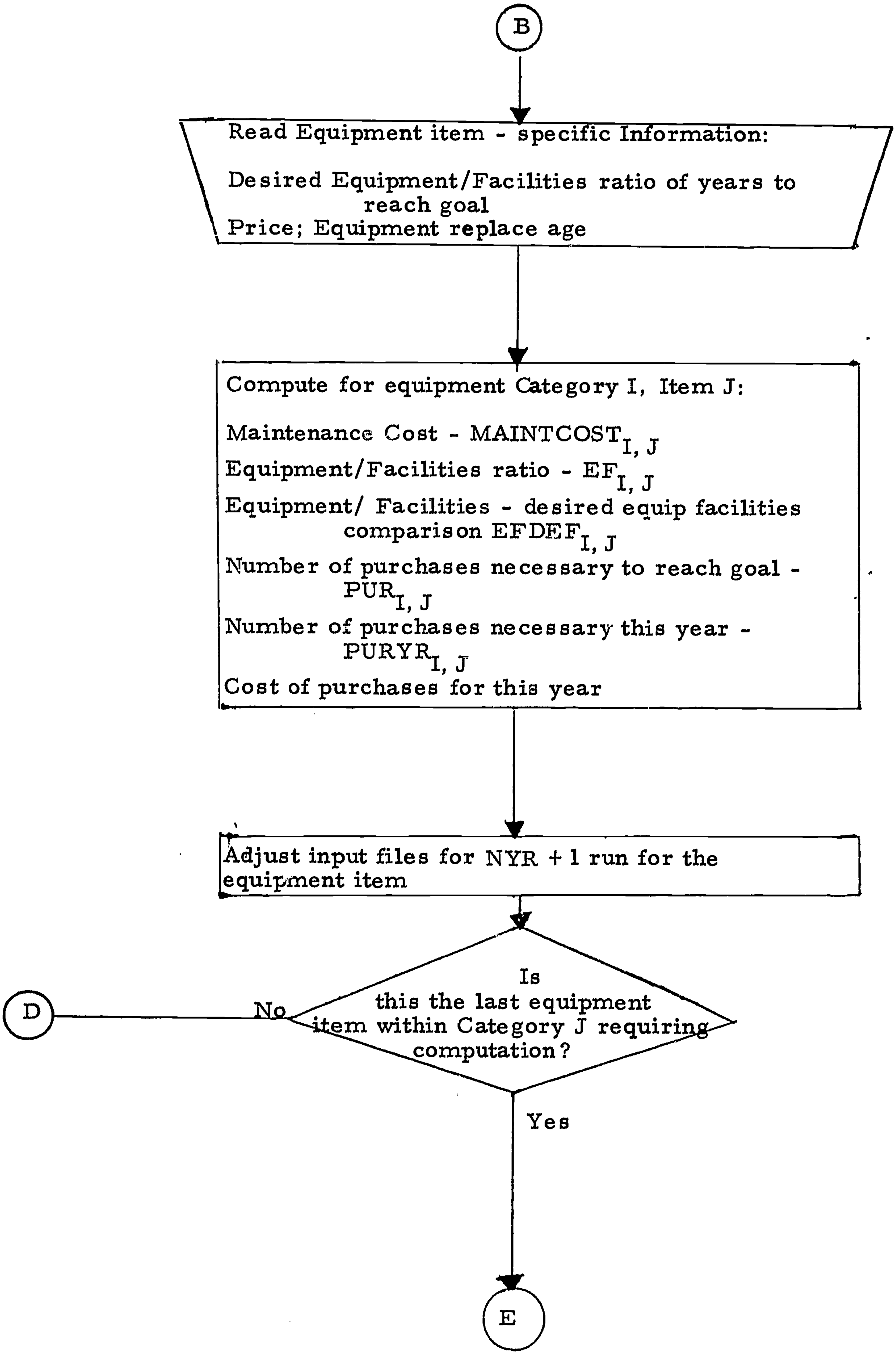
| | |
|---|---|
| $TOTCOST_{NSC}$ | Cost for each school of all equipment purchases |
| $TOTMAINT_{NSC}$ | Cost for each school of all equipment maintenance |
| $MAINT_{NAG}$ | Summary of equipment maintenance costs, all categories by agency |
| $PURCH_{NAG}$ | Summary of equipment purchase costs, all categories by agency |
| $AGITIN_{NAG,I}$ | Summary of inventory, by category and agency |
| $AGITMAINT_{NAG,I}$ | Summary of maintenance costs, by category and agency |
| $AGCOST_{NAG,I}$ | Summary of purchase costs, by category and agency |
| $AGEFDEF_{NAG,I}$ | Summary of equipment/facilities - desired equipment/facilities ratio, by category and agency |
| $ARMAINT_{NAR}$ | Summary of maintenance costs, all categories by area |
| $ARPURCH_{NAR}$ | Summary of purchase costs, all categories by area |
| $ARITIN_{NAR,I}$ | Summary for categories of equipment by area, inventory |
| $ARITMAINT_{NAR,I}$ | Summary for categories of equipment by area, maintenance cost |
| $AREFDEF_{NAR,I}$ | Summary for categories of equipment by area, equipment/facilities - desired equipment/facilities ratio |
| BMAINT | BIA equipment maintenance costs, all categories |
| BPURCH | BIA equipment purchase costs, all categories |

BIA EQUIPMENT PROJECTION MODEL

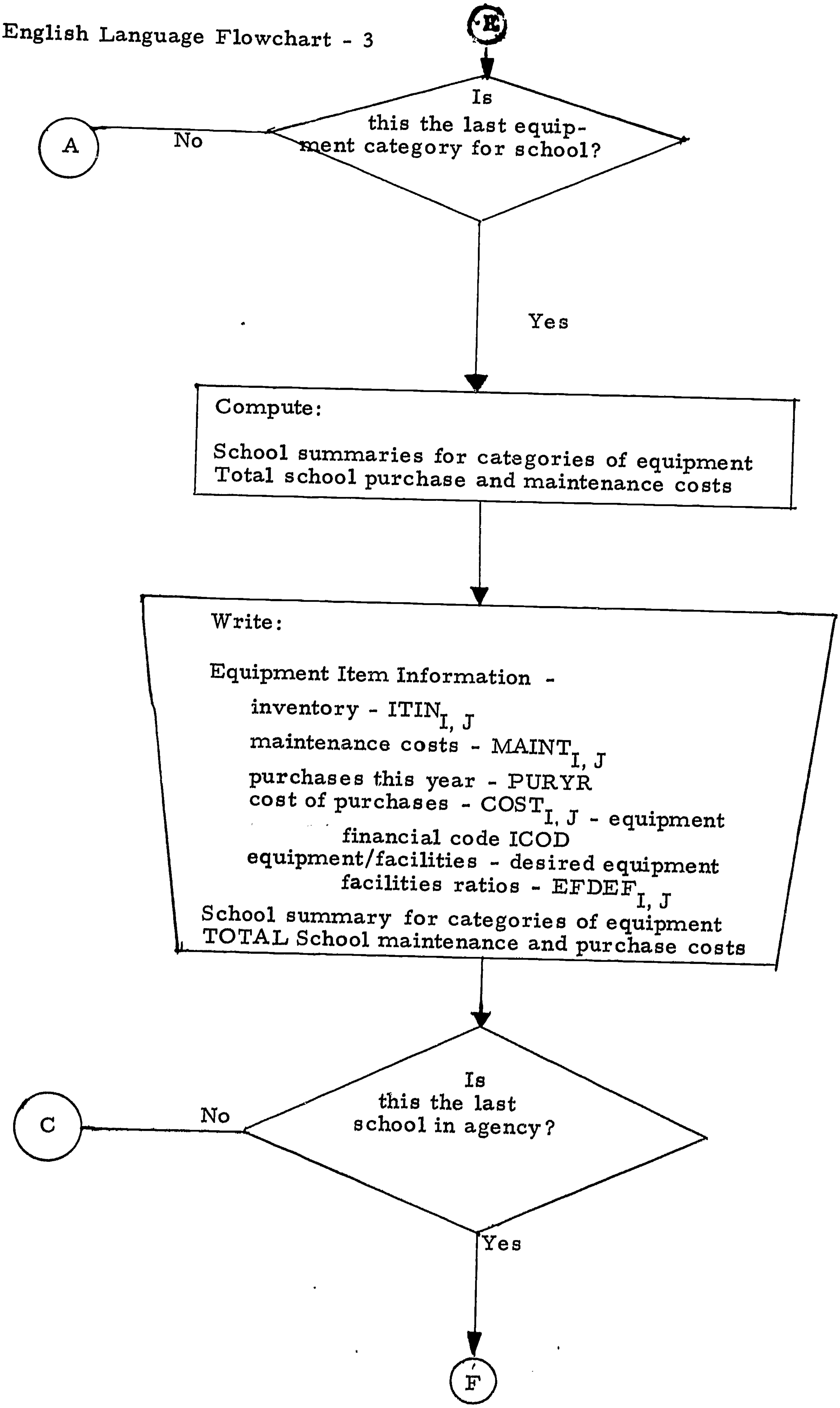
English Language Flowchart



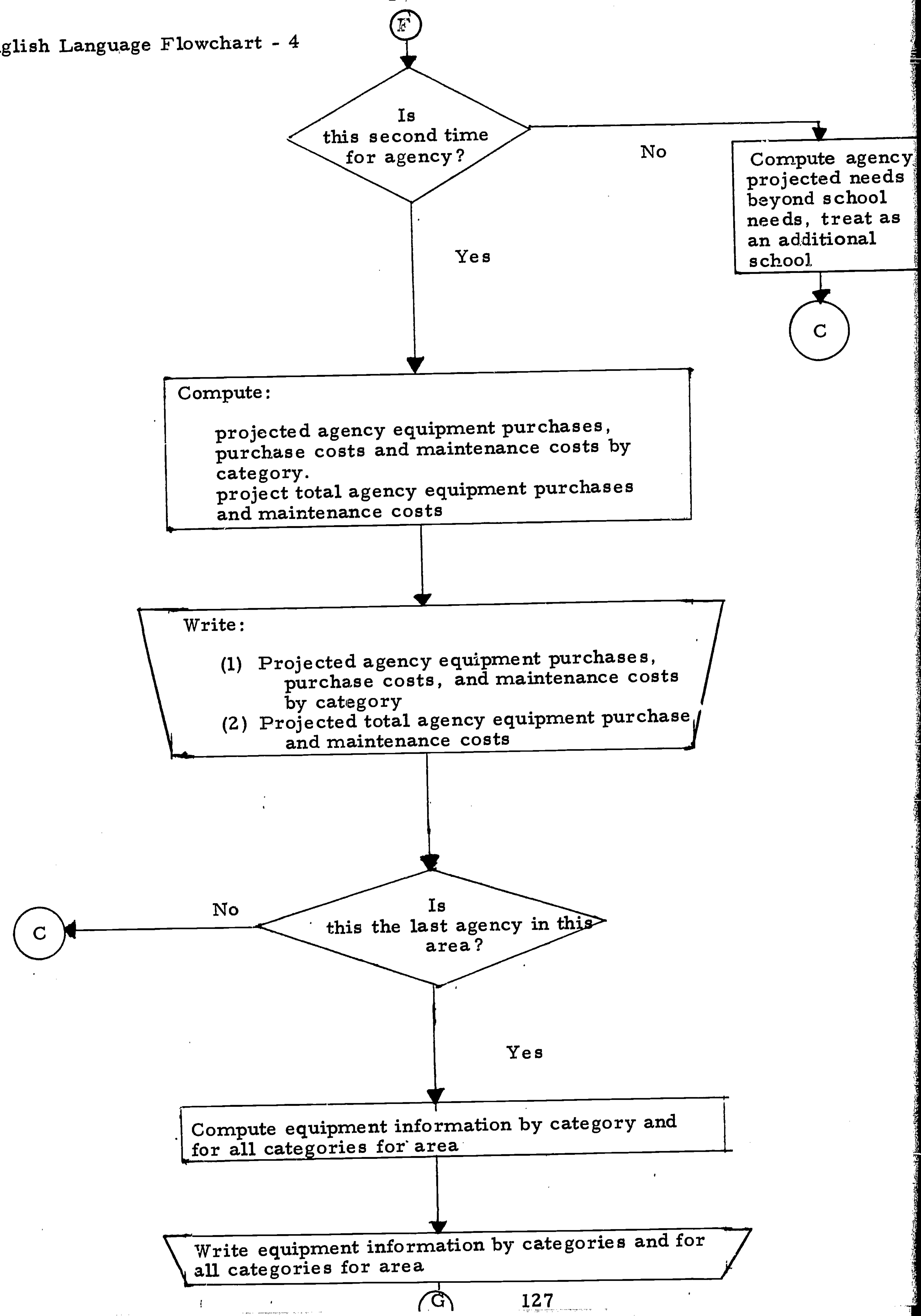
English Language Flowchart - 2



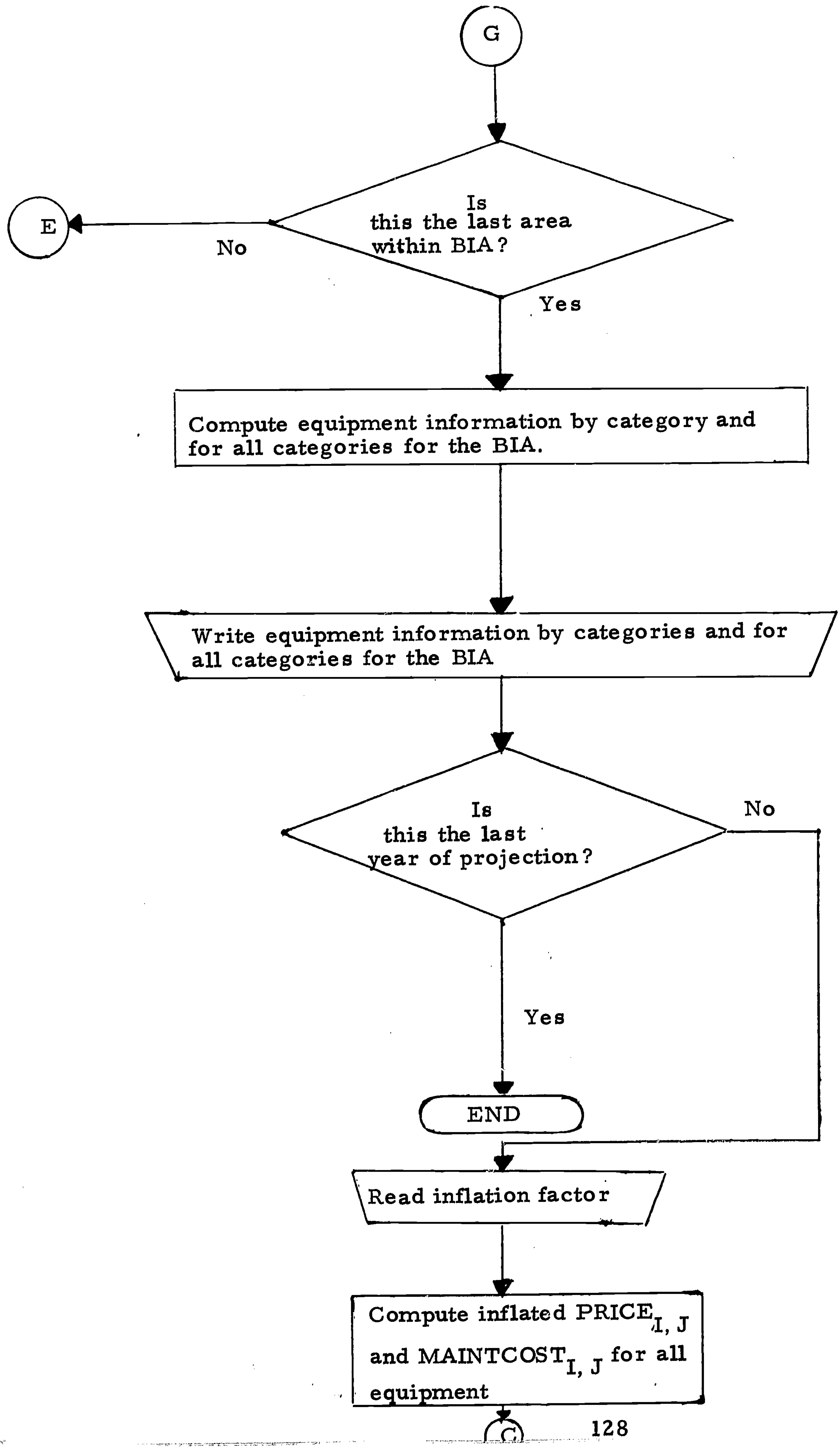
English Language Flowchart - 3



English Language Flowchart - 4



English Language Flowchart - 5



BIA EQUIPMENT PROJECTION MODEL

Detailed Mathematical Flowchart

START

↓

Reserve space for all subscripted variables

↓

Define:

| | | |
|---|---|---|
| NYRTOT | - | Year range of projection |
| NARTOT | - | Number of areas |
| $NAGTOT_{NAR}$ | - | Number of agencies within each area |
| $NSCTOT_{NAG, NAR}$ | - | Number of schools within each agency and area |
| ITOT | - | Range of equipment categories |
| $JTOT_{I}$ | - | Number of equipment item types within each category I |
| LTOT | - | Number of equipment age categories |

↓

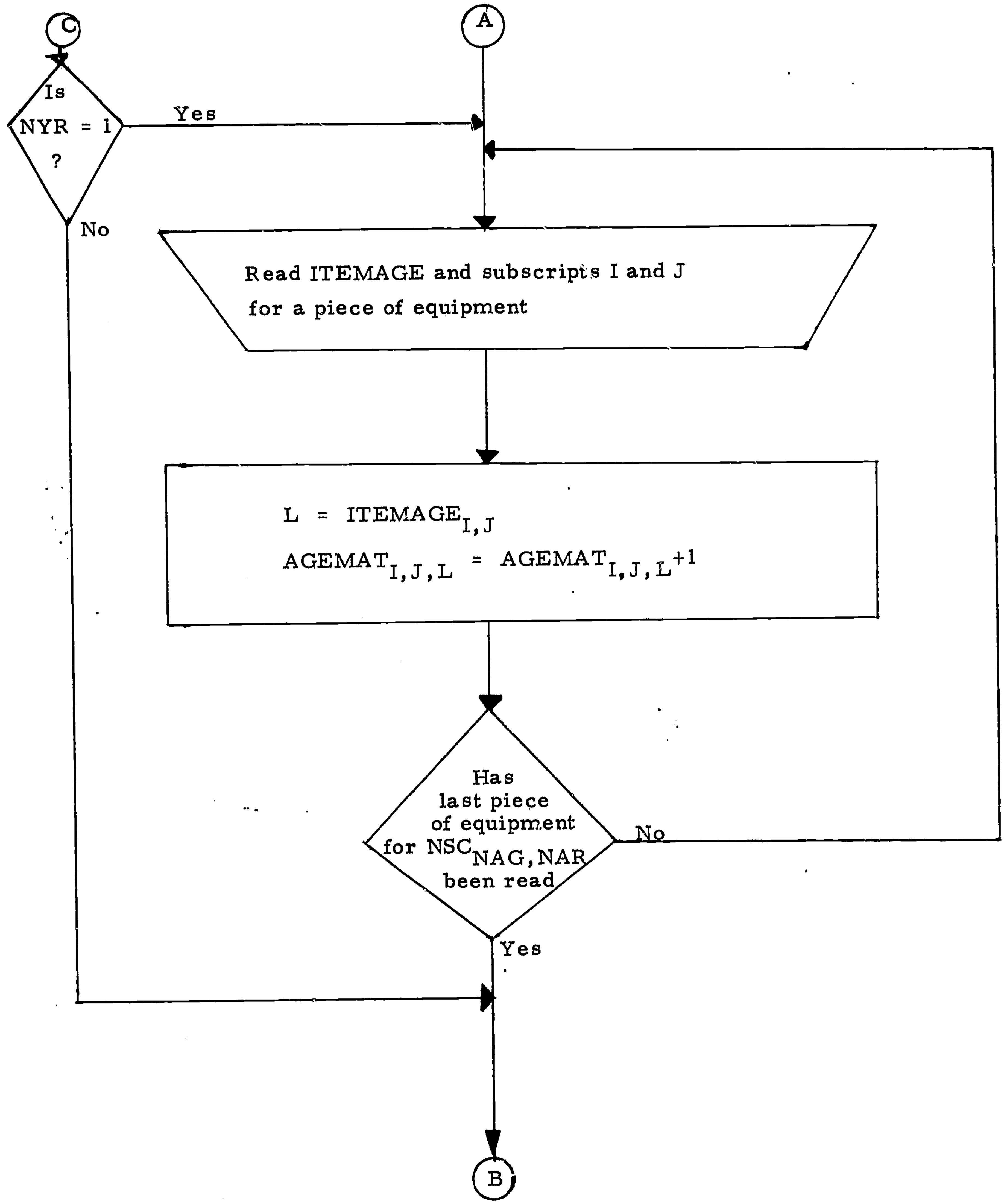
Initialization:

NYR = 1
NAR = 1
NAC = 1
NSC = 1
IFLAG = 1

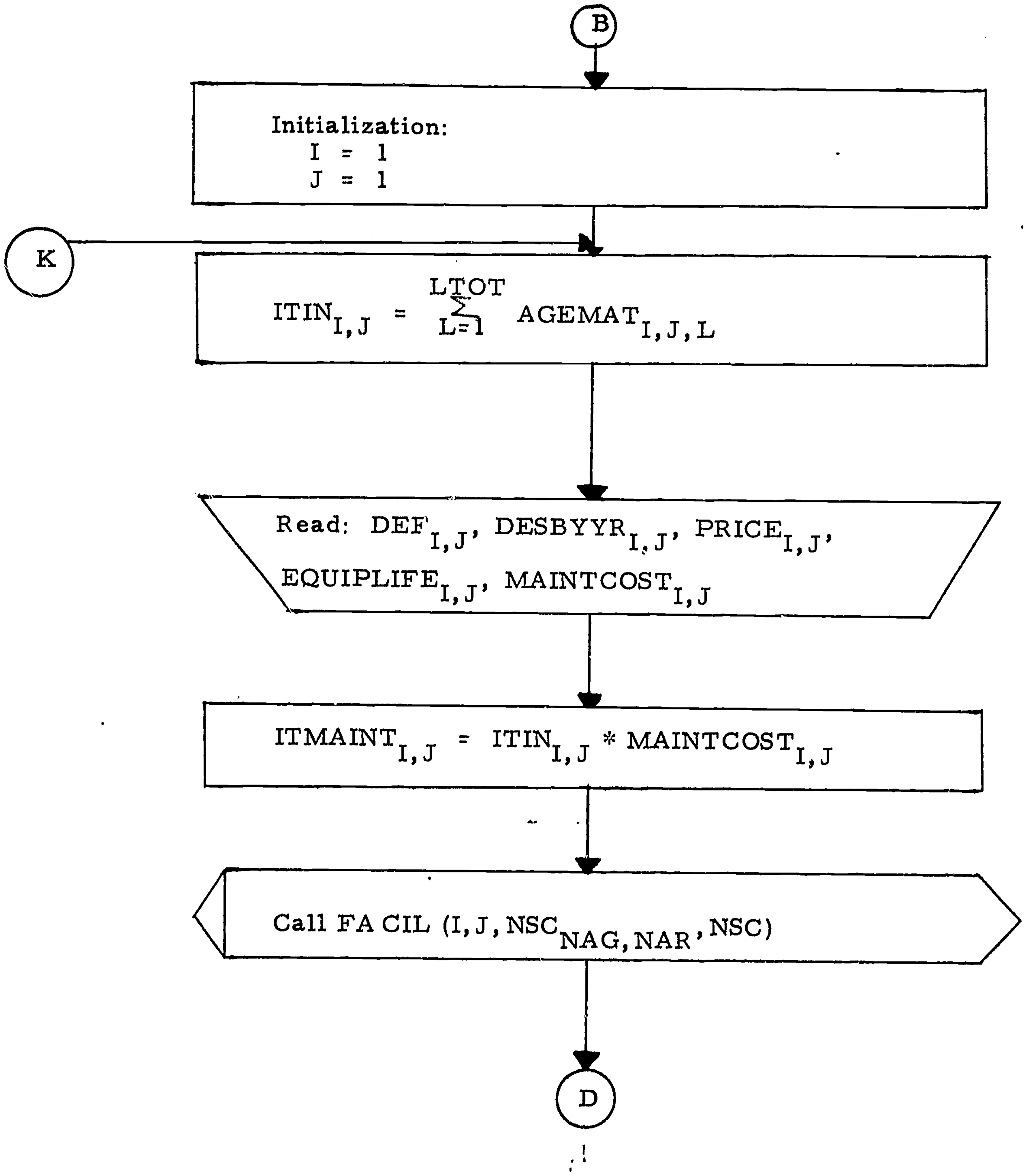
↓

(A)

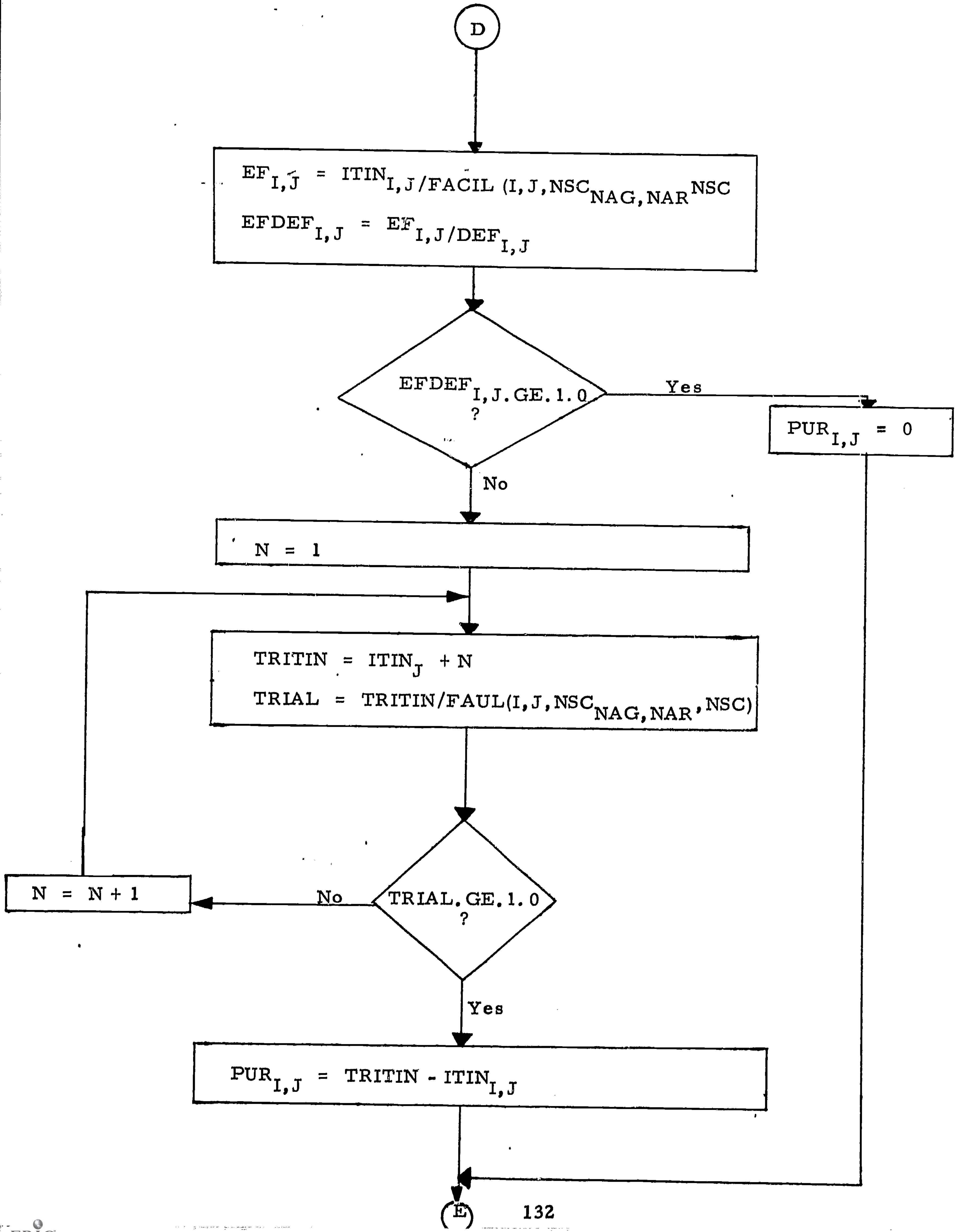
Detailed Mathematical Flowchart - 2

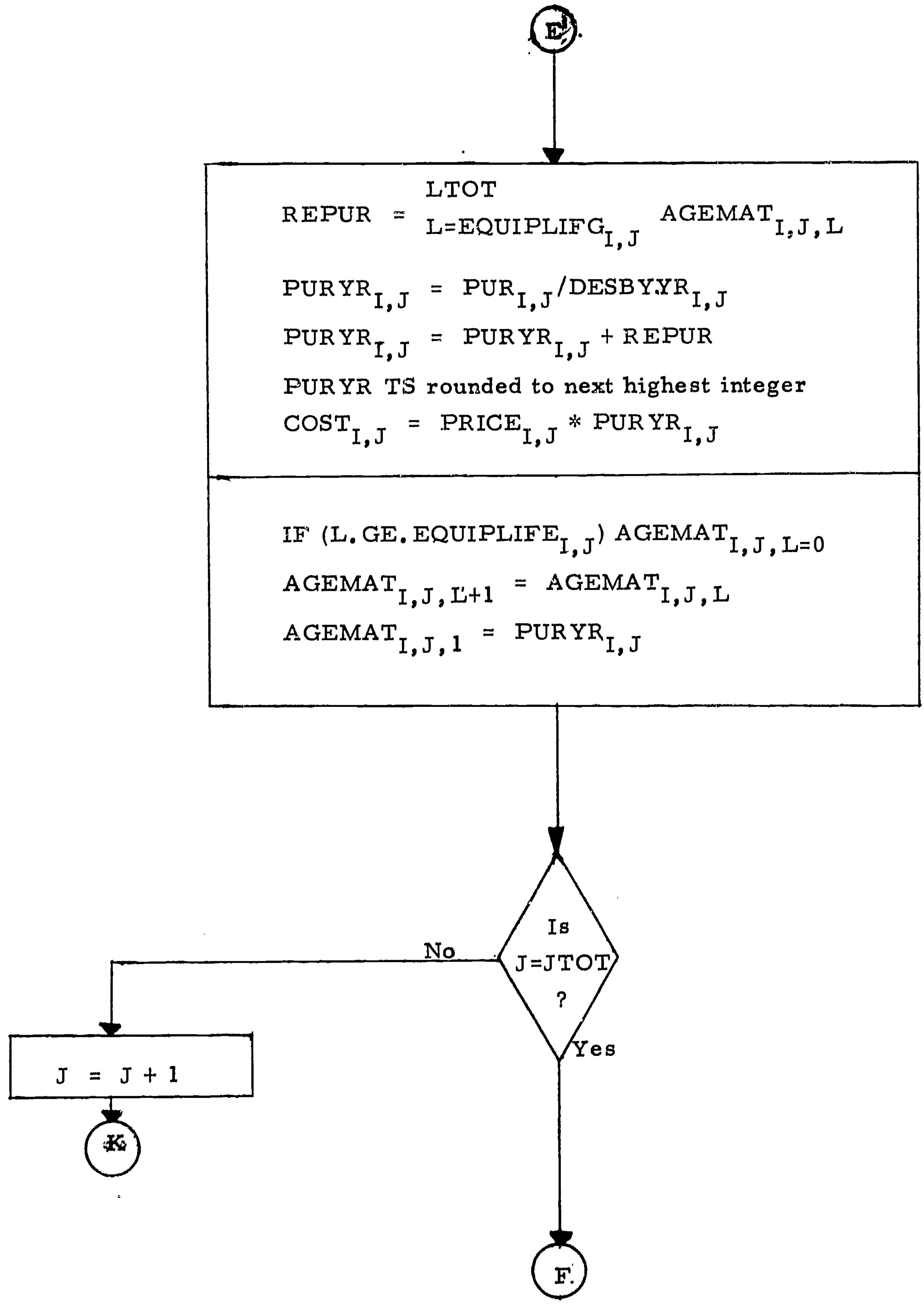


## Detailed Mathematical Flowchart - 3



## Detailed Mathematical Flowchart - 4




E
$REPUR = \sum_{L=EQUIPLIFG_{I,J}}^{LTOT} AGEMAT_{I,J,L}$
$PURYR_{I,J} = PUR_{I,J}/DESBYYR_{I,J}$
$PURYR_{I,J} = PURYR_{I,J} + REPUR$
PURYR TS rounded to next highest integer
$COST_{I,J} = PRICE_{I,J} * PURYR_{I,J}$
IF $(L.GE.EQUIPLIFE_{I,J})$ $AGEMAT_{I,J,L=0}$
$AGEMAT_{I,J,L+1} = AGEMAT_{I,J,L}$
$AGEMAT_{I,J,1} = PURYR_{I,J}$
Is J=JTOT ?
No
Yes
J = J + 1
K
F

(F)

$SITIN_I = \underset{J = 1}{\overset{JTOT_I}{}} \; ITIN_{I,J}$

$SPURYR_I = \underset{J = 1}{\overset{JTOT_I}{}} \; PURYR_{I,J}$

$SITMAIN_I = \underset{J = 1}{\overset{JTOT_I}{}} \; ITMAINT_{I,S}$

$SCOST_I = \underset{J = 1}{\overset{JTOT_I}{}} \; COST_{I,J}$

$SEPDEF_I = \underset{J = 1}{\overset{JTOT_I}{}} \; JTOT_I$

Is $I = ITOT_J$ ?

No → $I = I + 1$, $J = 1$ → (K)

Yes ↓

$TOTCOST_{NSC,NAR,NAR} = \underset{I = 1}{\overset{JTOT}{}} \; SCOST_I$

$TOTMAINT_{NSC,NAG,NAR} = \underset{I = 1}{\overset{ITOT}{}} \; SITMAINT_I$

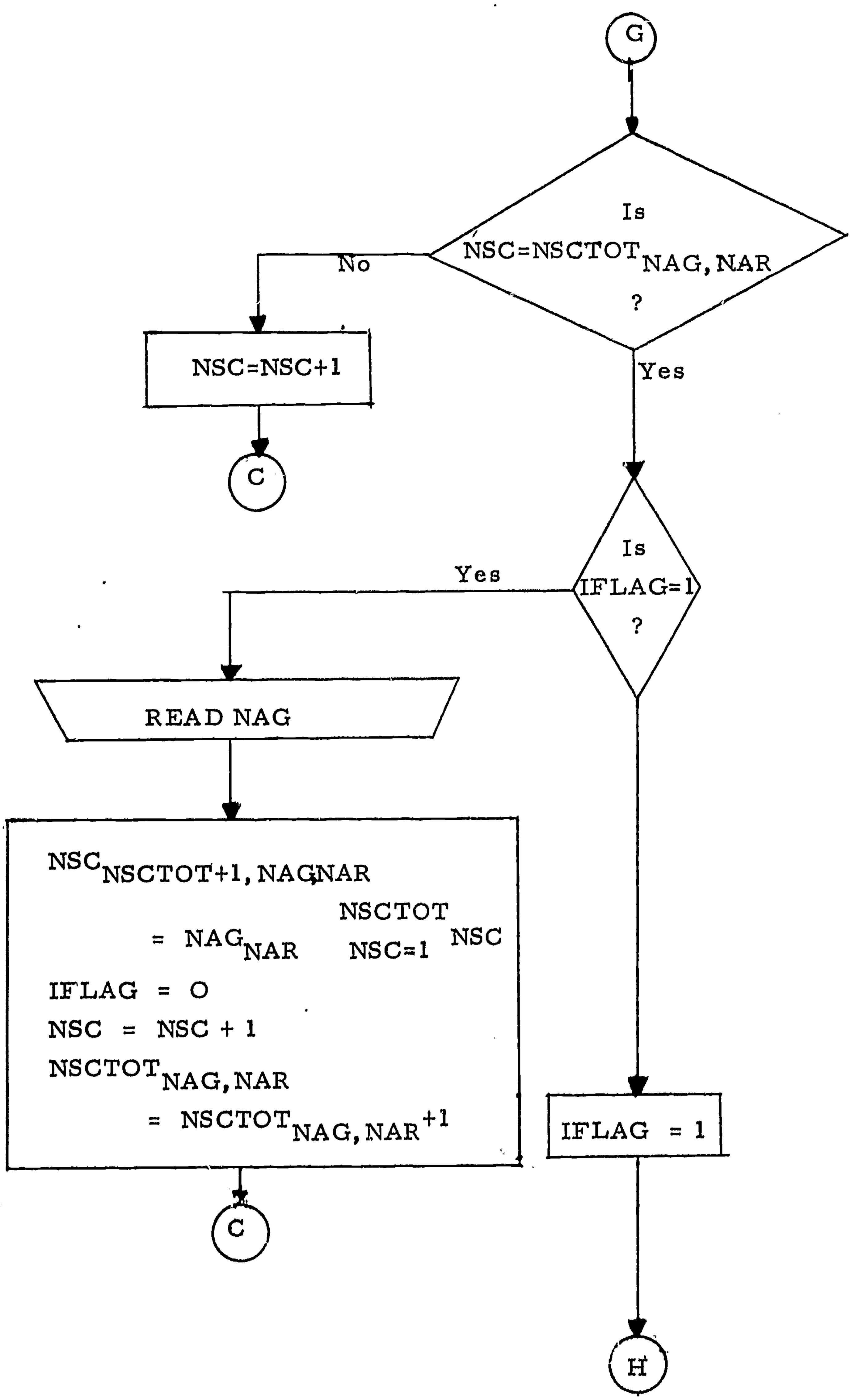
Write: $ITIN_{I,J}$, $ITMAINT_{I,J}$, $PURYR_{I,J}$, $COST_{I,J}$, ICOD, $EFDEF_{I,J}$

$SITIN_I$, $SITMAINT_I$, $SPURYR_I$, $SCOST_I$, $SEFDEF_I$

$TOTMAINT_{NSC,NAG,NAR}$, $TUTCOST_{NSC,NAG,NAR}$

(G)

Detailed Mathematical Flowchart - 7



H

$$AGITIN_{NAG, I} = \sum_{NSC=1}^{NSCTOT_{NAG, NAR}} SITIN_{NSC, I}$$

$$AGITMAINT_{NAG, I} = \sum_{NSC=1}^{NSCTOT_{NAG, NAR}} SITMAINT_{NSC, I}$$

$$AGPURYR_{NAG, I} = \sum_{NSC=1}^{NSCTOT_{NAG, NAR}} SPURYR_{NSC, I}$$

$$AGCOST_{NAG, I} = \sum_{NSC=1}^{NSCTOT_{NAG, NAR}} SCOST_{NSC, I}$$

$$AGEFDEF_{NAG, I} = \left( \sum_{NSC=1}^{NSCTOT_{NAG, NAR}} SEFDEF_{NSC, I} \right) \Big/ NSCTOT_{NAG, NAR}$$

$$SAGITMAINT_{NAG} = \sum_{I=1}^{ITOT} AGITMAINT_{NAG, I}$$

$$SAGCOST_{NAG} = \sum_{I=1}^{ITOT} AGCOST_{NAG, I}$$

WRITE: $AGITIN_{NAG, I}$; $AGITMAINT_{NAG, I}$; $AGPURYR_{NAG, I}$; $AGCOST_{NAG, I}$; ICOD; $AGEFDEF_{NAG, I}$; $SAGITMAINT_{NAG}$; $SAGCOST_{NAG}$

I

(I)

Is $NAG = NAGTOT_{NAR}$ ?

No:

$NAG = NAG + 1$
$NSC = 1$

(C)

$$ARITIN_{NAR, I} = \sum_{NAG=1}^{NAGTOT_{NAR}} AGITIN_{NAG, I}$$

$$ARITMAINT_{NAR, I} = \sum_{NAG=1}^{NAGTOT_{NAR}} AGITMAINT_{NAG, I}$$

$$AREFDEF_{NAR, I} = \sum_{NAG=1}^{NAGTOT_{NAR}} AGEFDEF_{NAG, I} \quad NAGTOT_{NAR}$$

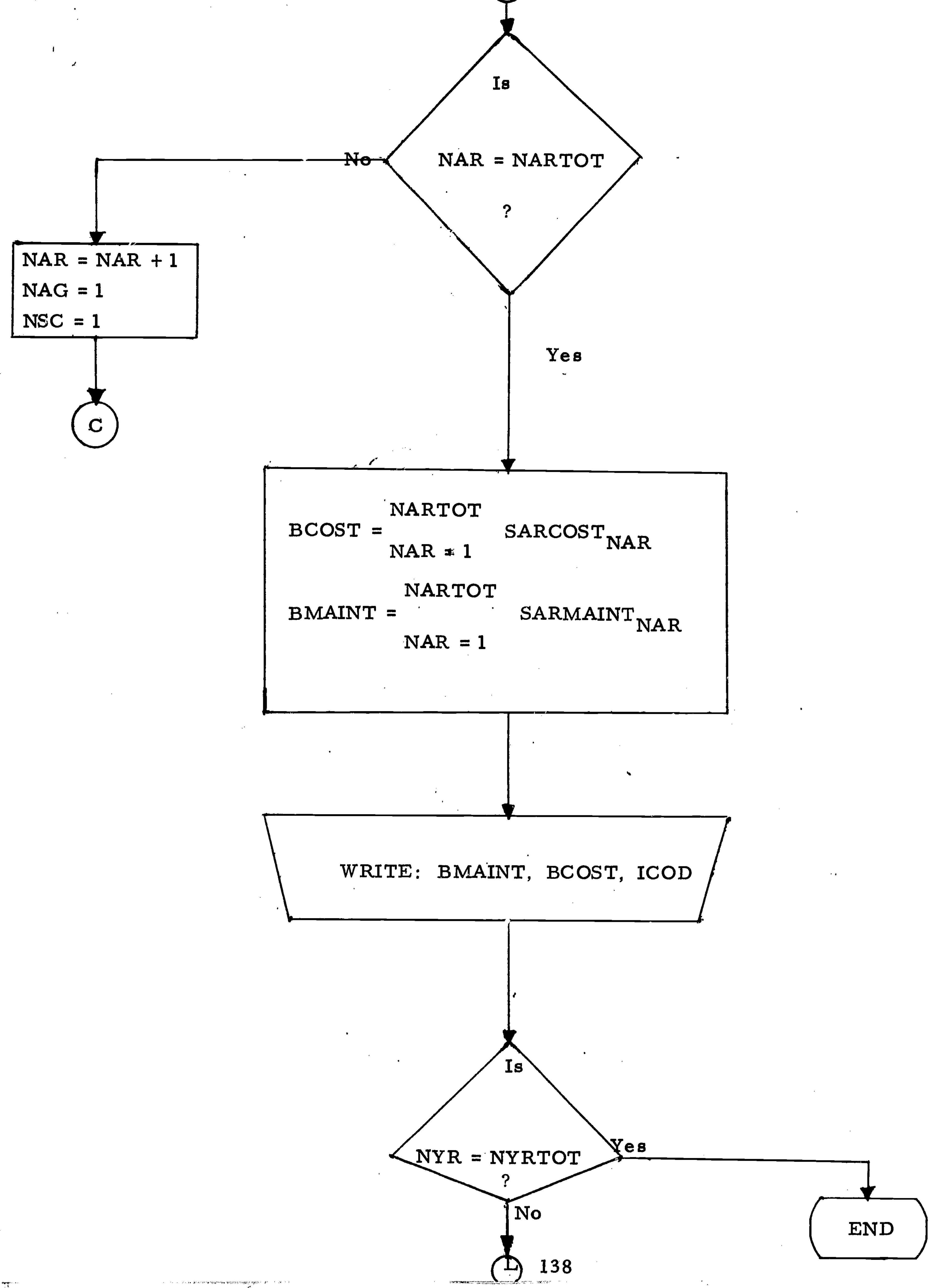
$$SARMAINT_{NAR} = \sum_{NAG=1}^{NAGTOT_{NAR}} SAGITMAINT_{NAG}$$

$$SARCOST_{NAR} = \sum_{NAG=1}^{NAGTOT_{NAR}} SAGCOST_{NAG}$$

WRITE: $ARITIN_{NAR, I}$; $ARITMAINT_{NAR, I}$; $AREFDEF_{NAR, I}$, $SARMAINT_{NAR}$; $SARCOST_{NAR}$; ICOD

(J)

## Detailed Mathematical Flowchart - 10



Detailed Mathematical Flowchart - 11

(L)

READ BLOWUP

$PRICE_{I, J*} (1 + BLOWUP)$

for all I and J

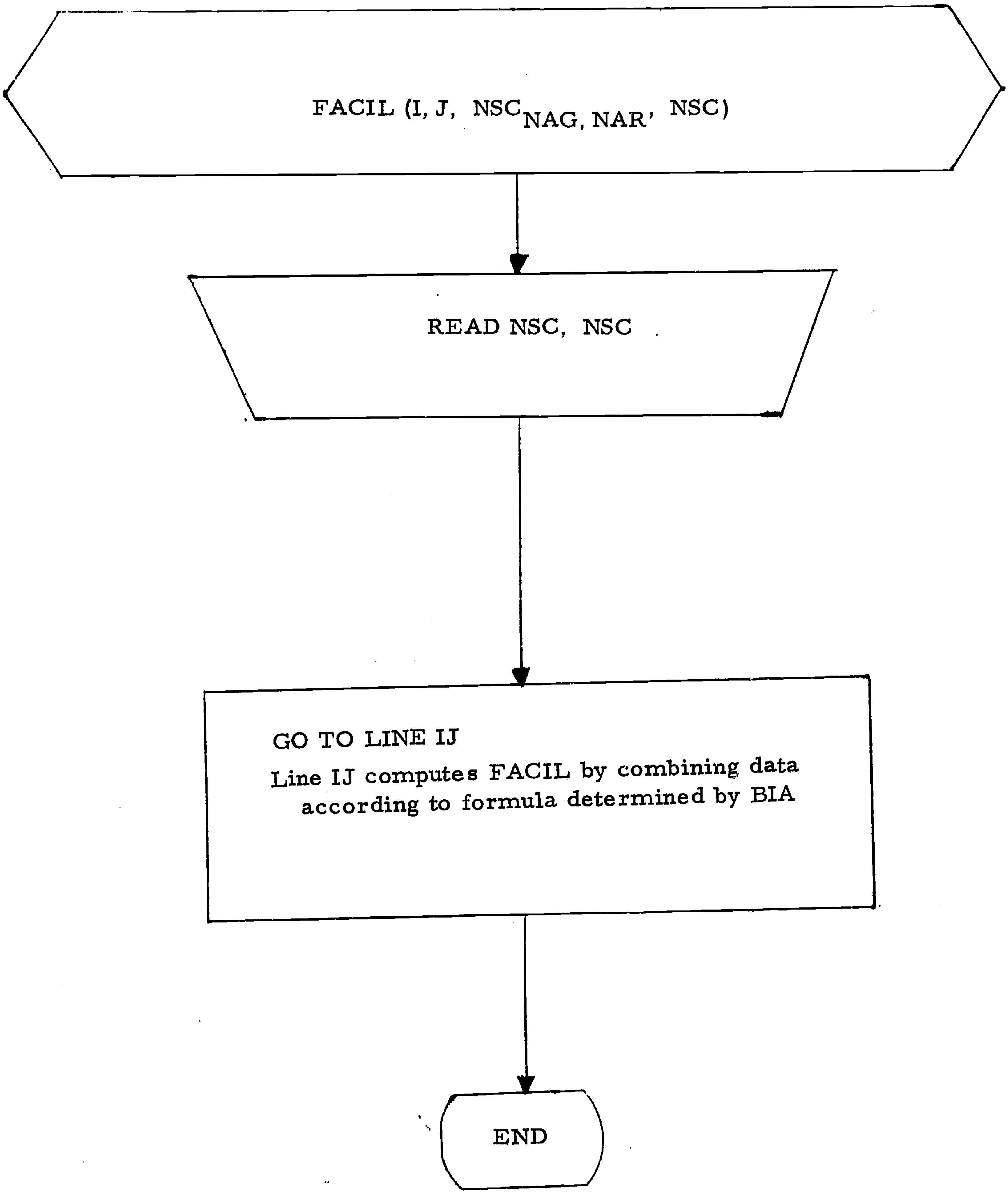
$MAINTCOST_{I, J} = MAINTCOST_{I, J*} (1 + BLOWUP)$

for all I and J

$NYR = NYR + 1$
$NAR = 1$
$NAG = 1$
$NSC = 1$

(C)

Detailed Mathetical Flowchart - 12



# Chapter VIII

# Finance Management Information System Model

## INTRODUCTION

### A Short History of the MIS Effort

The direction of the MIS effort has undergone significant evolution since June, 1968. The original plan of action was to begin with an investigation of the information/decision system in existence at all levels of the Education Division's administrative structure from the school principal to the Washington office. The purpose of this effort was to identify the structural weaknesses and discontinuities which were thought to be inhibiting the most efficient operation of the educational system. The study was to provide recommendations for the removal of these decision-making problems as well as to develop tools for improving the efficiency of each administrative level.

It soon became apparent that implementation of such recommendations would not be enough to ensure efficient management. Visits to the Washington Office, Area and Agency Offices and schools indicated that inadequate, untimely, or non-existent information was just as important as the structural weaknesses of the system. The existing information quality and flow doomed even the best decision-makers to great dependence on intuition and word-of-mouth reports and ensured that a very sophisticated management information system could not presently be implemented. Thus, the MIS effort was re-oriented to include the development of a basic but comprehensive system of data collection, manipulation and transcription which would enable managers to correct short-term operating aberrations, to adjust school-year policies to meet unexpected operating problems and to plan short- and long-term programs which will fit changing needs.

### The Need for a Financial Planning Model

While the need for regular reports of information concerning operating conditions is seldom questioned, the desirability of a financial planning model needs more careful explanation because of its more esoteric purposes. Unless program plans and policy decisions can be tied directly to their immediate and long term costs, they can command only minimal respect from both those who supply the funds and those who receive the benefits. Congress demands the delineation of specific needs for funds as well as measures of the effectiveness of dollars spent. Congress also wants to know the long term implications of its approval of various expenditures. For example, if a certain dollar per pupil food allotment is approved, what will this cost in ten years. Those who are receiving benefits and those who represent the recipients want to know why only certain expenditures have been approved and how much can be expected in years to follow. Thus, the need is for a method of bringing together the programs, plans and policies of an administrative unit (such as a reservation) in dollar terms so that overall costs can be seen at a glance. This method must also be able to project these costs over time assuming response-to-need changes in program and policies. In this way the fund appropriators, program administrators and benefit recipients can clearly see comprehensive cost implications. Also, such a methodology should be able to easily and cheaply express these cost estimates for a selection of program-policy package alternatives so that overall area costs can be compared as well as individual program costs.

A mathematical model obviously is the only instrument which can handle the complexity of data which must be included to satisfy the expressed need for the total cost implications of an area's policy-program plans. The computerization of this model is clearly indicated by the requirements for time series estimates and the testing of various combination packages; only a computer model can perform such arduous, time-consuming tasks cheaply and rapidly.

Generally the need for a financial MIS model stems from the Education Division's present haphazard, discontinuous planning methods and these methods' failure to improve the educational performance of the American Indian. A mechanism is needed that will provide decision-making data regularly and that will allow for coordinated long-term planning. This kind of sophisticated planning further demands a model adequate to the demands of educational programs development, funding and implementation placed on the Education Division school and area administrators by the Bureau of the Budget, and an ever-watchful Congress. This model is designed to meet those demands.

## The Objectives of the Design Program

The objectives established for the design of the model were derived directly from the constraints implicit in the needs for such a model. It was decided that the model must accept as input cost outputs from other relevant planning models (Personnel Projection Model, Enrollment Projection Model, etc.,), and data concerning policy decisions. This latter data will include costs due to policy changes not associated with the other planning models (e.g., current social studies curriculum is changed and all new textbooks are needed) and changes in supplies and materials that are due to increased enrollment and which are not projected by the other planning models. These inputs insure a comprehensive coverage of a location's proposed expenditures.

Operationally, it was decided that the model should be capable of iterating its projections as requested. Of course this is necessary for the time series evaluation of the effects of approval of certain policies.

It was determined that the model output would pull all yearly projected expenditures into a line item form which is both familiar to planners, Congress and recipients and comparable across locations.

## The Methodology of Development

The model was developed with an eye on both the objectives and the computer requirements. All objectives were assumed as specifications and inputs; processes or outputs were created to meet the requirements. These were then arranged in a flow-chart which accounted for the list processing and iterative nature of the model. Mathematical specifications can easily be derived from this chart (see below, pp. ).

## The Model in Context of an Overall MIS

It should be understood that the Financial MIS Model is only a small part of the Education Division MIS program. Monthly exception and quarterly control reports form the basis of the MIS in that they will provide the information needed by operating management to maneuver on-going programs within design and budget constraints.(see formats designed, Volume V, Appendix ). Status reports will provide the summary information which will indicate the program alternatives and policy changes necessary or desirable in future years' plans. Only when a set of program-policies have been created from this information does the Financial MIS Model come into play. It will present the time series budget projected by each complete plan for the purpose of graphically displaying the total costs of a collection of programs and policies which have been selected individually on an empirical cost/benefit basis.

## The Concept of the Model's Design Constraints

There was only one major structural constraint on the design of the model; it was felt that the existing cost code system of line item budgeting had to be used because of its integral part in the existing computerized financial accounting system. This is unfortunate because the cost category, cost element and cost code structure and detail of this system are often not as relevant to programs as would be desirable. However, the availability and familiarity of the system out-weigh its deficiencies.

Another constraint of sorts was the necessity of building the model as an appendage, dependent on the output of several other predictive models. Of course this design was dictated by the decision to make the Financial MIS Model primarily a data converter-accumulator rather than generator. However, this design does tie the model's validity, if not actual operation, to the successful operation of several other predictive models.

## The Theoretical Design

The plan for the Financial MIS Model is quite simple. The initial input required by the model is a listing of the previous school year's expenditures by line item at the location (With certain exceptions to be explained). These line items (cost code totals) are then divided by the actual previous year's enrollment to get a current dollar-per-pupil expenditure. To these figures would then be added the next input, the dollar-per-pupil expenditure change policies. The output of this calculation would be the planned dollar-per-pupil-per-cost code expenditure which, when multiplied by the input of projected enrollment, would generate the projected line item budget with exceptions. The exceptions would next be inputed from the cost calculations done by the new facilities, personnel, equipment and equipment maintenance projection models. When added to the budget with exceptions, the complete projected line item would be generated for output as well as preparation for input for the next year's projection iteration. This preparation would simply involve the removal of the line item exceptions.

Essentially, the model is designed as a simple list processor as opposed to a complex calculator. It takes old and new line item costs, planned dollar-per-pupil policies and enrollment changes and produces a familiar budget statement. This allows not only cheap, efficient production on a computer so that many packages can be tested, but also makes hand calculation of a limited number and time series feasible in the absence of the computer program or a complete set of the input essentials.

INPUTS

To begin operation of the model, this data will have to be derived external to the model from the total previous year's accounts for the reservation or school under consideration. Of course this input will have to exclude those line items which account for personnel facilities, equipment and equipment maintenance expenditures since these items will be calculated directly by the appropriate projection models. Along with an enrollment figure for the reservation, this input represents the initialization coefficients on which the projection will be based.

For the second and subsequent iterations of the model these inputs will be derived internally. The expenditures per cost code input will be the one period lagged complete output of the model minus the exception line items. Likewise, current enrollment will be a one term lagged version of the previous projected enrollment.

The changes in per pupil expenditure policy input will be a listing per cost code of the positive or negative per pupil expenditure policy, alterations. Of course such listings will have to be imputed for each iteration the model must run.

The projected enrollment input must be derived from an interpretation of the population projection model's output. A linear formula could directly convert the population estimates into enrollment projections. Except for the first year, the validity of the FMIS model will depend on the accuracy of the translation of the population growth output.

The Personnel, Facilities, Equipment and Equipment Maintenance projection models will internally calculate the costs relevant to the status and growth (or decline) which they estimate. This data will be outputed from these models in the line item and cost code form which is familiar to the FMIS model.

These projection models could be run completely independently of the FMIS model and their cost outputs sequentially stored on tape by iteration for later input to the FMIS.

### Operation of the Model - Standard Operation

Normal running of the FMIS model requires that all time series input be complete. This means the projective models (including the population one) must have completed as many iterations as is required of the FMIS model and the relevant output available for input. Similarly the dollar-per-pupil policies must be prepared for as many periods as the model is to be run. Should any of these inputs be missing, the computer monitor could be designed to either stop the run or substitute dummy figures (for example, the previous period's figure) so that calculations (valid for those cost codes uneffected by the absence of data) could be completed.

Computer requirements for standard operation would be rather slight because of the data-processing as opposed to calculation intensive nature of the model. Thus, many program packages for all locations could be run rather cheaply. However, this model is dependent on numerous inputs which can be developed only by the other projective models which are more calculation intensive. Hence, the overall expense of making numerous comparison runs could be considerable.

### Manual Operation

Because of the simplicity of the calculations, the FMIS model can indeed be used for hand calculation of budget estimates. The step-by-step logic of the design can easily be followed by a man with a pencil. However, the manipulation through several iterations would be a very tedious task and would require considerable time. Estimating a number of program packages by this method, while not impossible, would not be very cost effective. Also, it should be mentioned that, even though the FMIS model can be used for hand calculation, the data requirements remain the same and much of this input is produced by models which are complex enough to require the use of the computer.

## OUTPUTS

The output format for the FMIS model must be both simple to interpret and relevant to the program-policy decision maker's variety of proposals.

One which does this must present both line items and the policy components which are related. The example below attempts this match.

Financial Management Information System Model - Output Format

Location: XXXXX

Number: XXXXX

Date: XX/XX/XX

Program Description: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Iteration Number: XXXXX

Corresponding Year: XXXX

Enrollment: XXXX

| Cost Category | Nomenclature | $/Pupil | Planned Expenditure | Change from Previous Year |
|---|---|---|---|---|
| | | | | |
| Totals | | (average) | (total) | (total) |

| Category Identifier | Cost Element | Nomenclature | $/Pupil | Planned Expenditure | Change from Previous Year |
|---|---|---|---|---|---|
| | | | | | |
| Totals | | | (average) | (total) | (total) |

| Category Element Identifier | Cost Code | Nomenclature | $/Pupil | Planned Expenditure | Change from Previous Year |
|---|---|---|---|---|---|
| | | | | | |
| Totals | | | (average) | (total) | (total) |

The Users and the Uses

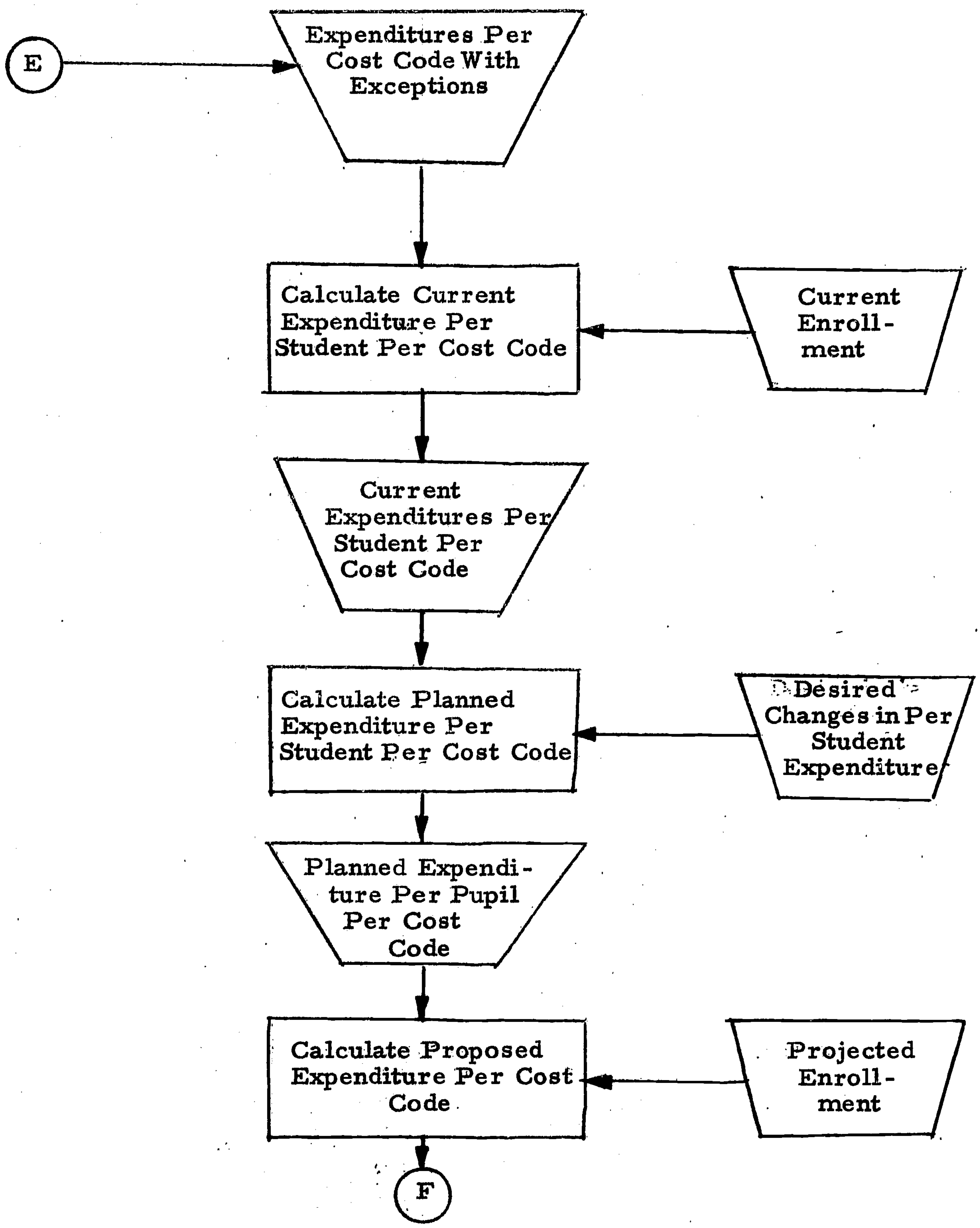
The output from the FMIS model is only a relatively high level planning tool because of its inclusive design. Ideally, the various location adminstration levels and the Washington Office using the other tools developed by Abt Associates, Inc. will be able to arrive at mutually acceptable ranges of programs for consideration. These sets of programs can then be prepared for input to the model with the purpose of determining the long range costs of the alternatives. The Washington Office can then compare the packages across locations using dollar-per-pupil and change measures to decide on the most acceptable program for each location. Total figures and policies from all locations could be added and resubmitted to the computer program to establish an overall BIA budget in time series. This could also be done by area, reservations and agencies.

The model output on the lowest level could be used to settle budget conflicts between schools, agency, areas, etc., and the Washington Office by consistently projecting costs directly in parallel with policy elements. At the Washington level, the Education Division Office can use the outputs from various locations testing sets of program packages to rationally decide allocations among them. Also, the Washington Office can use these outputs to justify budget requests from Congress both directly and indirectly. The output format shows costs compared to dollar-per-pupil policy and this delineation should answer most questions of the funds appropriators. However, any program package that actually does reach the appropriations request level should be supported in detail with qualitative and quantitative support material. This support can be provided by the output of several of the other models. The FMIS model will act primarily as a financial summary of program proposals, but as a justification of the program content.

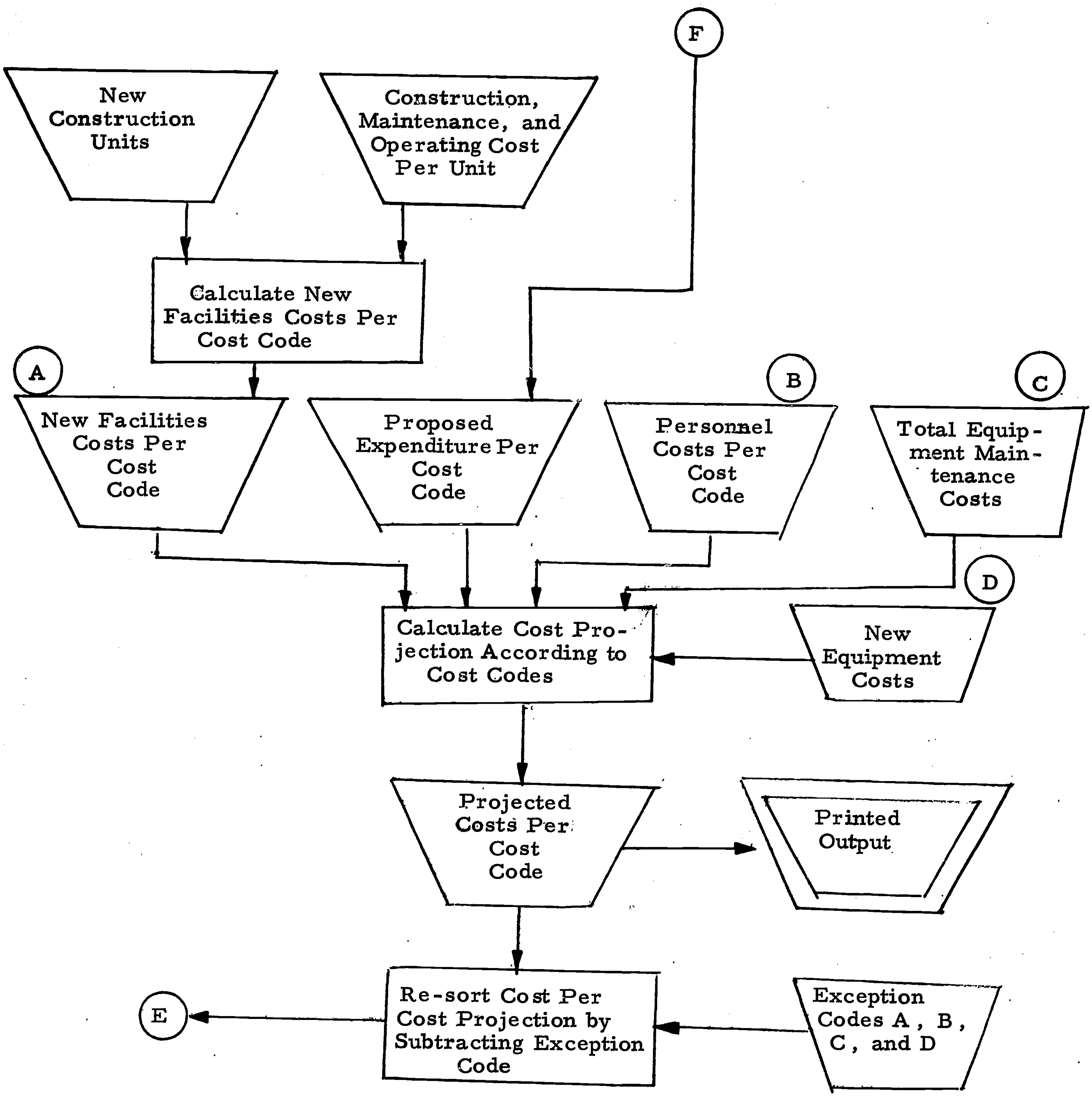
FINANCIAL MANAGEMENT INFORMATION SYSTEM

MODEL

English Language Flowchart



Financial MIS Model -- continued



# Chapter IX

## School Investment Model

### DESCRIPTION OF OBJECTIVES

The purpose of the School Investment Model is to determine a budget allocation for improving BIA education in a given set of schools, given information on school conditions, student performance, minimum standards, and budget goals.

The data enters the model in the form of matrices (one for each school and others for constants) and a map of school locations. The operations performed on the data are represented graphically by flow charts, described verbally, and then illustrated, step by step, in a specially developed example.

The model provides different methods of budgeting to meet each of three goals: raising all schools to some minimum standard (satisfying); obtaining the best possible educational standards with existing facilities (maximizing); and obtaining the best possible educational level with a limited budget (optimizing).

The output consists of a budget allocation dictated by purchases, hirings, student transfers, program and schedule modifications, and occasionally, school closings.

### Theoretical Description

(See School Investment Model Flowchart; box numbers correspond to steps in this description.)

Step 1: A group of indicators describing any school's performance is chosen, and a constant assigned to each variable, indicating its minimum acceptable standard. One set of minima must be established for each level of school, often for each grade. The variables chosen should be commonly available, such as achievement test scores, services provided to students, facilities, materials, and numbers and types of personnel.

Step 2: For the subset of variables describing student performance, such as examination scores, weights are determined to indicate the relative importances of these variables, or more accurately, the marginal value of raising a particular variable by a certain amount (say, one point) above its minimum standard. A useful mathematical tool for this purpose is the Churchman-Ackoff approximate measure of value procedure. The dimensions of the weights are value per student per point above minimum.

Step 3: Data collected about each of the indicator variables is compared with the minimum standards, producing a positive or negative figure depending on whether a given variable is above or below the standard.

Step 3.1: An estimate of cost per student per year is made for each school and grade, on the basis of the available information.

Step 4: If all the indicators for a school are above the minimum, go to step 6; if one or more indicators is below the minimum, go to step 5.

Step 5: An estimate of the cost per student per year to raise a given indicator a certain amount, approximated near the minimum standard, is made on the basis of the available information. Then, for those indicators that are below the minimum standard, the costs of raising them to the standard is calculated. For each sub-standard school, two overall costs are produced, the cost for the school and the cost per student in the school.

Step 6: For boarding schools that are at or above the minimum in each indicator, an estimate is made of the number of additional students that could be accommodated, without lowering any indicator below the minimum. This model is based on a Paretian concept of increasing the educational benefits received by some without decreasing those received by others. It is assumed that the cost per additional student is the same as the cost of current students.

Step 7: For all schools, the value rating of a school is calculated by multiplying the value weights of step 2 by the average amount above minimum, or zero if below minimum, of the respective indicators, and adding the products. The dimensions of these value ratings are value per student. For schools all of whose indicators are above the minimum, these value ratings are called "actual"; for those with some indicators below the minimum, the ratings are called "potential."

Step 8: One of three policy options is now chosen: the satisfying option raises all schools to the minimum standard at minimum cost; the maximizing option raises all schools to the highest possible standards, with no budgetary constraints, but using only the existing buildings and gross facilities; and the optimizing option provides the most improvement in education for a limited budget.

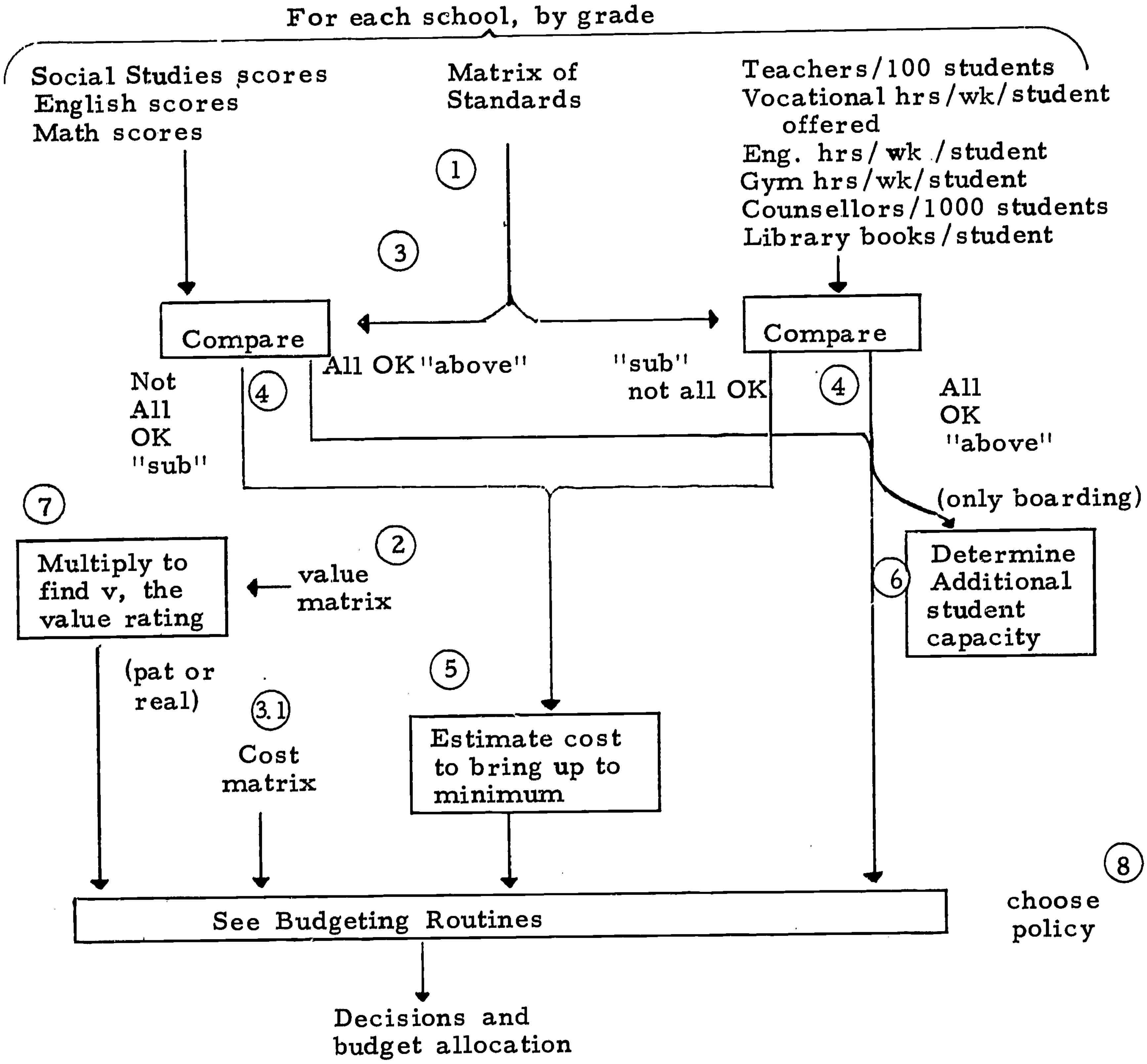
Step 9A: (See satisfying routine flow chart.) Day schools are automatically brought up to minimum standards according to step 5. Boarding schools are considered, beginning with the greatest cost per pupil to raise to minimum. If it is possible to transfer all students from this school into above-standard schools without exceeding a maximum distance from home, this is done and the school is closed. If not, the school is raised to the minimum standard according to step 5. This process is continued until all schools have either been closed or brought up to standard; the total cost is then calculated.

Step 9B: (See maximizing routine flow chart.) Day schools are automatically brought up to minimum standards according to step 5. Boarding schools are taken in pairs, beginning with the one with the highest and the one with the lowest value. As many students as possible are transferred from the lower to the higher, as long as there is room in the latter, and no student is transferred farther than a certain maximum distance from home. If the lower-valued school is emptied and there are still places left in the higher-valued school, then the next-lower-valued school is taken and the process continues; if the higher-valued school is filled and the lower-valued is not emptied, then the next-higher-valued school is taken and the process continues. If a school is partially emptied in this way, then it is brought up to a minimum according to step 5, but with the new enrollment figures. When the process cannot continue further, all remaining schools are raised to minimum standards according to step 5.

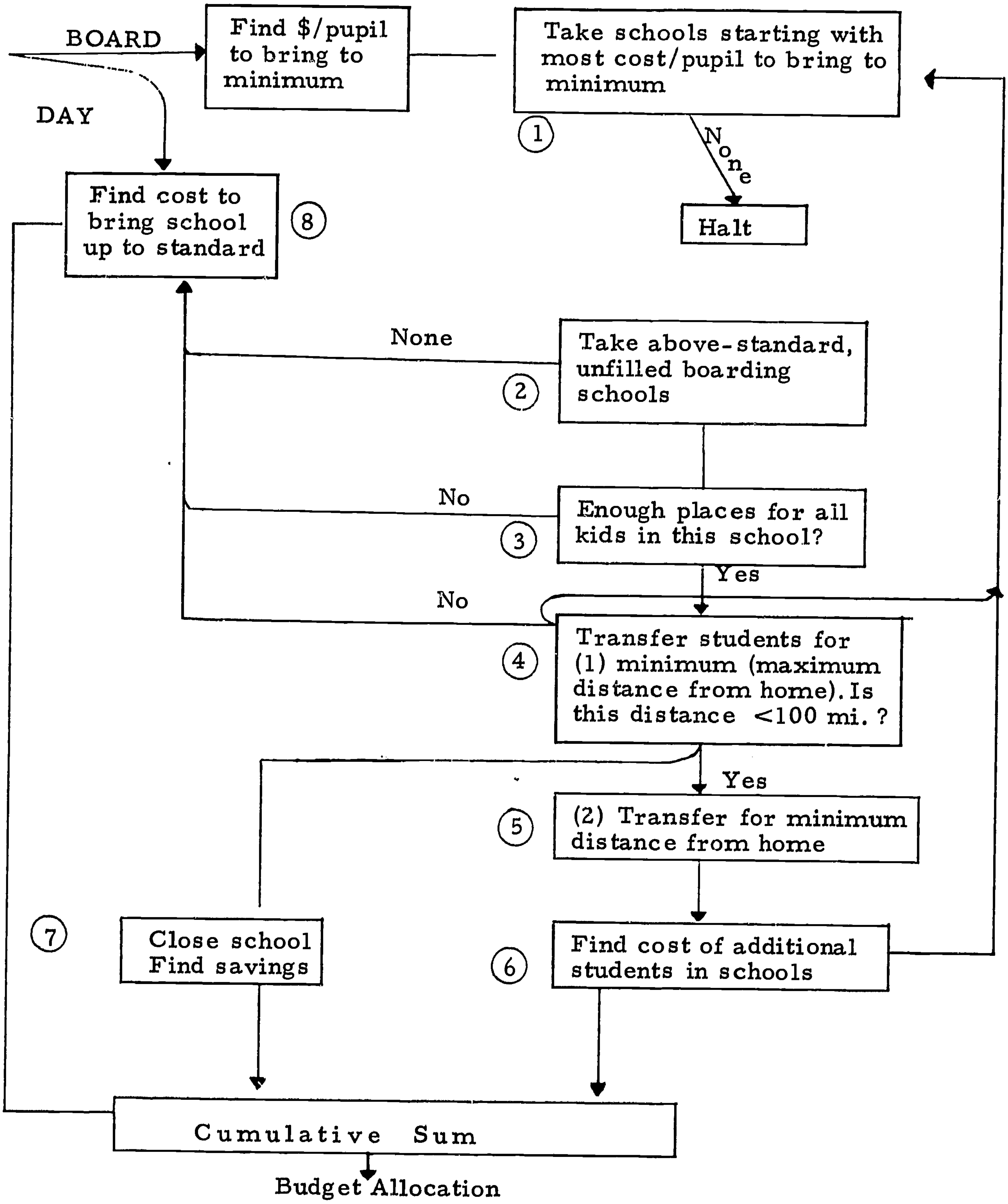
Step 9C: (See optimizing routine flow chart.) Two kinds of marginal cost-effectiveness are determined, covering all feasible programs of educational improvement. One is the marginal cost-effectiveness of transferring pupils from sub-standard to above-standard boarding schools, according to the change in school value per dollar per student. The other is marginal cost-effectiveness of raising both day and boarding schools up to minimum standards, according to the change in school value (already given by the "potential" value) per dollar per student. These options are arranged in order of cost-effectiveness, and the budget is allocated an item at a time on the best remaining option up to budgeted amounts.

SCHOOL INVESTMENT MODEL

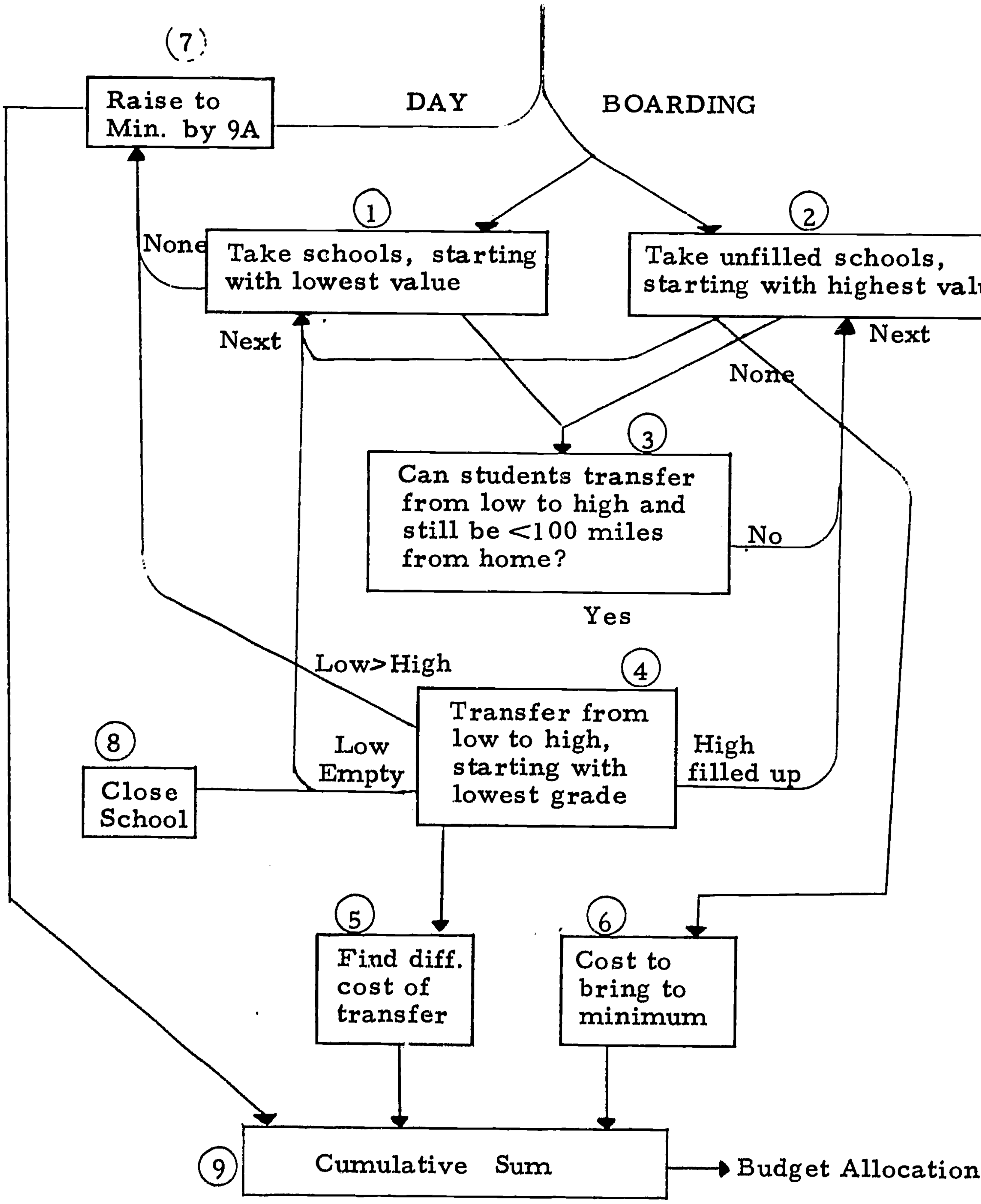
English Language Flowchart



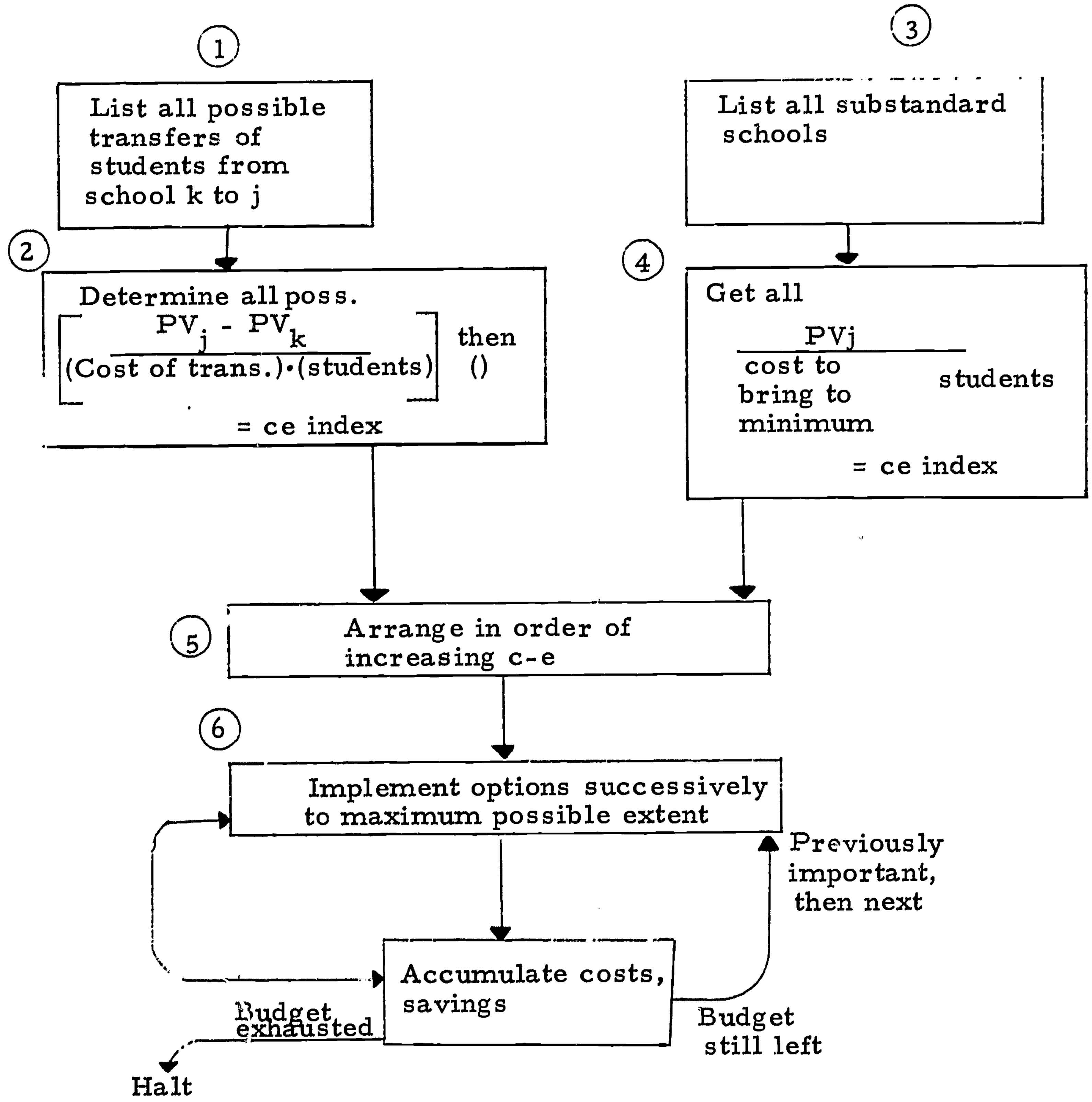

SCHOOL INVESTMENT MODEL FLOW CHART




SATISFYING ROUTINE FLOW CHART




MAXIMIZING ROUTINE FLOW CHART




OPTIMIZING ROUTINE FLOW CHART

## A PRACTICAL EXAMPLE

The specific numerical example that follows was developed to show the operation of the School Investment Model, and to help explain the three budget policy options it offers.

This example is derived from real possibilities, but is over-simplified both in that it only considers five schools and in that it uses only simple arithmetic operations for all calculations. A practical model would be able to deal efficiently with several hundred schools, and would use accurate iterative and statistical processes, e.g. correlation and the Churchman-Ackoff process.

Many simplifying assumptions are made about the situation described. For example, additional student capacity for boarding schools is taken as an input, when actually it should be derived secondarily from inputs. Also, it is assumed that each school's regular scheduling routine puts slower pupils in smaller classes and offers them a somewhat disproportionately great teacher/pupil ratio, so that each school, if isolated, would be operating as efficiently as possible, in the analytical sense of the model. To our knowledge, none of the assumptions made limits the generality of the model.

To make the best use of this example, the reader is advised to follow along each step with the flow charts of Part II, and with any matrices referred to in this part, as he reads the explanation of the processes performed.

A. Matrix Operations

Specifications for five hypothetical reservation schools were developed in order to demonstrate the operation of the Investment Model. Input to the model from the schools is given in sections (i.), (viii.), (xi.), and (xii.) of matrices describing the following variables, for each of three grades where applicable:

(i.) (1.) Social studies percentage scores
(2.) English percentage scores
(3.) Mathematics percentage scores
(4.) Teachers per 100 students
(5.) Vocational hours per week per student offered
(6.) Organized athletics hours per week per student
(7.) Condition of textbooks (0=poor, 1=fair, 2=good, 3=new)
(8.) Guidance counsellors per 1000 students
(9.) Library books per student
(viii.) (10.) Student enrollment
(xi.)(11.) School type (boarding or day)
(12.) Available extra boarding space
(13.) Cost per student per year, in thousands of dollars
(xii.)(14.) Distances between schools

In addition, inputs describing parameters of the school system are specified in sections (ii.), (iv.), and (vi.), as follows:

(ii.) Minimum constant standards for each variable (1.) through (9.)
(iv.) Assessed value per point above standards for variables (1.), (2.), and (3.)
(vi.) Cost per year per student per unit below standards, to raise to standards

The first operation performed on the input data is to subtract the minimum standards constant matrix from each of the school performance data input matrices, yielding a set of raw evaluation matrices indicated how far above or below standards each of the schools lies for each variable in each grade. (iii.)

Next, to determine values, either actual or potential, for each school, the scores over three grades for each of the three subject texts are added (iii. a. ), multiplied by the value constant matrix (iv. ), and the results added over the three tests for each school, yielding the final values (v. ). Since this routine is for evaluating each school's performance above the minimum standards, if a sum in (iii. a. ) is negative, it should be multiplied as zero.

To determine the cost to bring each school up to the minimum, the negative values of the raw evaluation matrices (iii. ) are multiplied by the satisficing cost constant matrix (vi. ) and the results made positive, yielding matrices at (vii. ), which express cost per year per student. These are, in turn, multiplied by the enrollment data input matrices (viii. ) expressing each school's cost per year, for each item. Summing all entries gives the total school cost per year (ix. ), and dividing by total enrollment yields per-student cost per year (x. ).

## School Summary

| | | | | |
|---|---|---|---|---|
| 1. | Boarding | Above-standard | Highest value | Medium size |
| 2. | Boarding | Above-standard | High value | Medium-large |
| 3. | Boarding | Sub-standard | Lowest value | Small |
| 4. | Boarding | Sub-standard | Medium value | Small |
| 5. | Day | Sub-standard | Low value | Large |

**i. School Performance Data Input Matrices**

| School No. | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Social Studies % | 52 | 60 | 62 | 53 | 58 | 61 | 37 | 65 | 52 | 58 | 63 | 59 | 49 | 53 | 57 |
| (2) English % | 70 | 75 | 83 | 67 | 75 | 81 | 58 | 75 | 80 | 60 | 67 | 75 | 50 | 50 | 53 |
| (3) Math % | 55 | 60 | 67 | 56 | 61 | 65 | 60 | 62 | 61 | 61 | 64 | 64 | 65 | 67 | 59 |
| (4) Teachers/100 | 4 | 3.7 | 3.6 | 3.9 | 3.5 | 3.7 | 2.5 | 3.3 | 3.6 | 2.2 | 2.9 | 3.6 | 3.5 | 3.3 | 3.4 |
| (5) Voc. hrs/wk/student | 2 | 7 | 7 | 0 | 5 | 5 | 0 | 0 | 0 | 1 | 6 | 6 | 0 | 7 | 7 |
| (6) Sports hrs/wk/student | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 4.5 | 4.5 | 4.5 | 5 | 5 | 5 |
| (7) Condition of texts | 2.5 | 2.5 | 2.8 | 2.6 | 2.7 | 2.9 | 2.1 | 2.2 | 2.3 | 1.8 | 1.9 | 2 | 1.7 | 1.9 | 2.1 |
| (8) Counsellors/1000 | 3 | | | 3.2 | | | 5 | | | 5 | | | 2.5 | | |
| (9) Lib. books/student | 3.2 | | | 3.1 | | | 2.4 | | | 2.6 | | | 3.5 | | |

(Subtract:)

**ii. Minimum Standards Constant Matrix**

| | | | |
|---|---|---|---|
| (1) | 52 | 55 | 57 |
| (2) | 65 | 70 | 73 |
| (3) | 55 | 60 | 62 |
| (4) | 3.3 | 3.3 | 3.6 |
| (5) | 0 | 5 | 5 |
| (6) | 4 | 4 | 4 |
| (7) | 2 | 2 | 2 |
| (8) | 2 | | |
| (9) | 3 | | |

(Yields:)

**iii. Raw Evaluation Matrices**

| | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0 | 5 | 5 | 1 | 3 | 4 | -15 | 10 | -5 | 6 | 8 | 2 | -3 | -2 | 0 |
| (2) | 5 | 5 | 10 | 2 | 5 | 8 | -7 | 5 | 7 | -5 | -3 | 2 | -15 | -20 | -20 |
| (3) | 0 | 0 | 5 | 1 | 1 | 3 | 5 | 2 | -1 | 6 | 4 | 2 | 10 | 7 | -3 |
| (4) | 0.7 | 0.4 | 0 | 0.6 | 0.2 | 0.1 | -0.8 | 0 | 0 | -1.1 | -0.4 | 0 | 0.2 | 0 | -0.2 |
| (5) | 2 | 2 | 2 | 0 | 0 | 0 | 0 | -5 | -5 | 1 | 1 | 1 | 0 | 2 | 2 |
| (6) | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 1 | 1 | 1 |
| (7) | 0.5 | 0.5 | 0.8 | 0.6 | 0.7 | 0.9 | 0.1 | 0.2 | 0.3 | -0.2 | -0.1 | 0 | -0.3 | -0.1 | 0.1 |
| (8) | 1 | | | 1.2 | | | 3 | | | 3 | | | -0.5 | | |
| (9) | 0.2 | | | 0.1 | | | -0.6 | | | -0.4 | | | 0.5 | | |

iii. Raw Evaluation Matrices

| | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0 | 5 | 5 | 1 | 3 | 4 | -15 | 10 | -5 | 6 | 8 | 2 | -3 | -2 | 0 |
| (2) | 5 | 5 | 10 | 2 | 5 | 8 | -7 | 5 | 7 | -5 | -3 | 2 | -15 | -20 | -20 |
| (3) | 0 | 0 | 5 | 1 | 1 | 3 | 5 | 2 | -1 | 6 | 4 | 2 | 10 | 7 | -3 |
| (4) | 0.7 | 0.4 | 0 | 0.6 | 0.2 | 0.1 | -0.8 | 0 | 0 | -1.1 | -0.4 | 0 | 0.2 | 0 | -0.2 |
| (5) | 2 | 2 | 2 | 0 | 0 | 0 | 0 | -5 | -5 | 1 | 1 | 1 | 0 | 2 | 2 |
| (6) | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 1 | 1 | 1 |
| (7) | 0.5 | 0.5 | 0.8 | 0.6 | 0.7 | 0.9 | 0.1 | 0.2 | 0.3 | -0.2 | -0.1 | 0 | -0.3 | -0.1 | 0.1 |
| (8) | 1 | | | 1.2 | | | 3 | | | 3 | | | 0.5 | | |
| (9) | 0.2 | | | 0.1 | | | -0.6 | | | -0.4 | | | 0.5 | | |

(If positive, yield 0; if negative, multiply by negative of:)

vi. Satisfying Cost Constant Matrix

(per unit per year per student)

| | |
|---|---|
| (1) | 7 |
| (2) | 8 |
| (3) | 8 |
| (4) | 100 |
| (5) | 20 |
| (6) | 15 |
| (7) | 5 |
| (8) | 15 |
| (9) | 2 |

(To yield:)

vii. Student Annual Satisfying Cost Matrices (Per Year Per Student)

| | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0 | 0 | 0 | 0 | 0 | 0 | 105 | 0 | 35 | 0 | 0 | 0 | 21 | 14 | 0 |
| (2) | 0 | 0 | 0 | 0 | 0 | 0 | 56 | 0 | 0 | 40 | 24 | 0 | 120 | 160 | 160 |
| (3) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 24 |
| (4) | 0 | 0 | 0 | 0 | 0 | 0 | 80 | 0 | 0 | 110 | 40 | 0 | 0 | 0 | 20 |
| (5) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| (6) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| (7) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.5 | 0 | 1.5 | 0.5 | 0 |
| (8) | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| (9) | 0 | | | 0 | | | 1.2 | | | 0.8 | | | 0 | | |

**vii. Student Annual Satisfying Cost Matrices**

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0 | 0 | 0 | 0 | 0 | 0 | 105 | 0 | 35 | 0 | 0 | 0 | 21 | 14 | 0 |
| (2) | 0 | 0 | 0 | 0 | 0 | 0 | 56 | 0 | 0 | 40 | 24 | 0 | 120 | 160 | 160 |
| (3) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 24 |
| (4) | 0 | 0 | 0 | 0 | 0 | 0 | 80 | 0 | 0 | 110 | 40 | 0 | 0 | 0 | 20 |
| (5) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| (6) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| (7) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.5 | 0 | 1.5 | 0.5 | 0 |
| (8) | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| (9) | 0 | | | 0 | | | 1.2 | | | 0.8 | | | 0 | | |

**viii. (Multiply rows 1 - 7 by → (10) and 8, 9 by → )**

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (10) | 550 | 500 | 450 | 650 | 650 | 600 | 40 | 30 | 30 | 45 | 35 | 30 | 700 | 700 | 650 |
| Total | 1500 | | | 1900 | | | 100 | | | 110 | | | 2500 | | |

**Enrollment Data Input Matrices**

**viii. a.**

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0 | 0 | 0 | 0 | 0 | 0 | 4.2k | 0 | 1.1k | 0 | 0 | 0 | 14.7k | 9.8k | 0 |
| (2) | 0 | 0 | 0 | 0 | 0 | 0 | 2.2k | 0 | 0 | 1.8k | 840 | 0 | 84k | 112k | 104k |
| (3) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 240 | 0 | 0 | 0 | 0 | 0 | 15.6k |
| (4) | 0 | 0 | 0 | 0 | 0 | 0 | 3.2k | 0 | 0 | 5k | 1.4k | 0 | 0 | 0 | 13k |
| (5) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3k | 3k | 0 | 0 | 0 | 0 | 0 | 0 |
| (6) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| (7) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 45 | 18 | 0 | 1.1k | 350 | 0 |
| (8) | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| (9) | 0 | | | 0 | | | 120 | | | 88 | | | 0 | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ix. (Sum yields:) | 0 | 0 | 0 | 0 | 0 | 0 | 9.7k | 3k | 4.3k | 6.9k | 2.3k | 0 | 99.8k | 113.2k | 132.6k |
| School Cost → | 0 | | | 0 | | | 17k | | | 9.2k | | | 345.6k | | |
| (Dividing by Enrollment yields:) | 1500 | | | 1900 | | | 100 | | | 110 | | | 2500 | | |
| x. Per Student Cost → | 0 | | | 0 | | | 170 | | | 92 | | | 138 | | |

| School Number | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0 | 5 | 5 | 1 | 3 | 4 | -15 | 10 | -5 | 6 | 8 | 2 | -3 | -2 | 0 |
| (2) | 5 | 5 | 10 | 2 | 5 | 8 | -7 | 5 | 7 | -5 | -3 | 2 | -15 | -20 | -20 |
| (3) | 0 | 0 | 5 | 1 | 1 | 3 | 5 | 2 | -1 | 6 | 4 | 2 | 10 | 7 | -3 |

iii. a.
Raw Evaluation Partial Matrices

(Sum each row; then, if negative, yield 0, and if positive, multiply by:)

iv. Value Constant Matrix

| | |
|---|---|
| (1) | 1 |
| (2) | 2 |
| (3) | 1.5 |

(Yields:)

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| (1) | 10 | 8 | 0 | 16 | 0 |
| (2) | 40 | 30 | 10 | 0 | 0 |
| (3) | 7.5 | 7.5 | 9 | 18 | 21 |

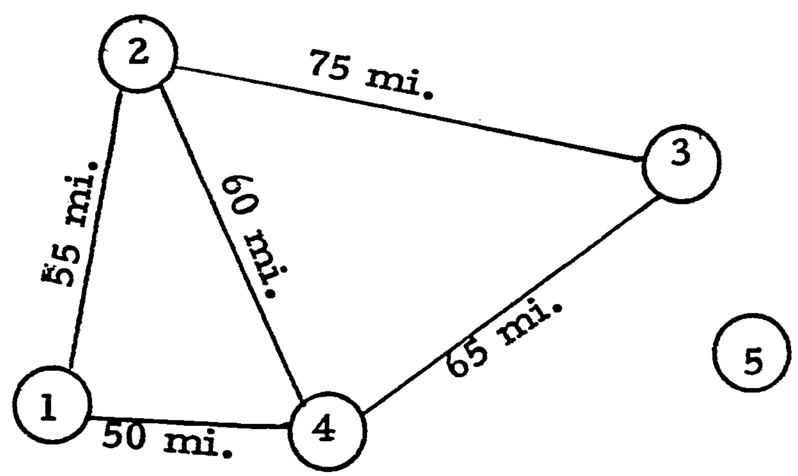
(Summing Yields:)

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| v. School Values | 57.5 | 45.5 | 19 | 34 | 21 |

## Additional Data

| | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| xi. Schooltype | (11) | B | B | B | B | D |
| Boarding Available | (12) | 60 | 80 | 10 | 20 | – |
| $k 1st./year | (13) | 2.7 | 2.5 | 2.2 | 2.4 | 2.0 |

xii. Geographic Distances (14)



B. Satisfying Routine

The relevant data in this example are as follows:

| | School No. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| xii. | (Map) | | | | |
| x. | Per-student Satisfying Cost | 0 | 0 | 170 | 92 |
| xi. | Boarding Space | 60 | 80 | 10 | 20 |
| viii. | Enrollment | 1500 | 1900 | 100 | 110 |
| ix. | School Satisfying Cost | 0 | 0 | 17k | 9.2k |
| xi. | Regular Cost per Student per Year | 2.7k | 2.5k | 2.2k | 2.4k |

Following the flow chart for the satisfying routine and using the above data, the following steps result:

1. (See x.) School 3.
2. (See ix., si.) Schools 1, 2.
3. (See xi, viii.) Yes.
4. (See xii.) No--too far away.
8. (See ix.) Cost is 17k. Enter in cumulative sum.
1. (See x.) School 4.
2. (See ix., xi.) Schools 1, 2.
3. (See xi, viii.) Yes.
4. (See xii.) Yes.
4. (See xi.) Send 45 students to school 1, 65 to school 2.
5. (See xi.) Cost is (45 x 2.7k) + (65 x 2.5k) = 284k. Enter in cumulative sum.
7. (See viii. and xi.) Saving is (110 x 2.4k) = 264k. Enter in cumulative sum.
8. (See ix.) School 5 to minimum standards costs 345.6k. Enter in cumulative sum.
9. (See above) Cumulative sume is (17k + 284k - 264k + 345.6k) = 382.6k.

C. Maximizing Routine

The relevant data in this example are as follows:

| | School Number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| xii. | (Map) | | | | |
| v. | Values, Actual or Potential | 57.5 | 45.5 | 19 | 34 |
| xi. | Regular Cost per Student per Year | 2.7k | 2.5k | 2.2k | 2.4k |
| viii. | Enrollment | 1500 | 1900 | 100 | 110 |
| xi. | Boarding Space | 60 | 80 | 10 | 20 |

The last two rows will be repeated as a matrix at various stages, in order to keep track of the changes in those figures.

Following the flow chart for the maximizing routine, and using the above data, the following steps result:

1. (See v.) School 3, low-valued.
2. (See v.) School 1, high-valued.
3. (See xii.) Transfer from 3 to 1? No.
2. (See v.) School 2, high-valued.
3. (See xii.) Transfer from 3 to 2? Yes.
4. (See xi.) Transfer 80 from 3 to 2.

| | | | |
|---|---|---|---|
| 1500, | 1980, | 20, | 110 |
| 60, | 0, | 90, | 20 |

5. (See xi.) Cost is 80(2.5k - 2.2k) = 24k. Enter in cumulative sum.
2. (See v.) School 4, high-valued.
3. (See xii.) Transfer from 3 to 4? Yes.
4. (See xi.) Transfer 20 from 3 to 4.

| | | | |
|---|---|---|---|
| 1500, | 1980, | 0, | 130 |
| 60, | 0, | 110, | 0 |

5. (See xi.) Cost is 20(2.4 - 2.2) = 4k. Enter in cumulative sum.
1. (See v.) School 4, low-valued.
2. (See v.) School 1, high-valued.
3. (See xii.) Transfer from 4 to 1? Yes.
4. (See xi.) Transfer 60 from 4 to 1.

| | | | |
|---|---|---|---|
| 1560, | 1980, | 0, | 70 |
| 0, | 0, | 110, | 60 |

5. (See xi.) Cost is 60(2.7k - 2.4k) = 18k. Enter in cumulative sum.

C. Maximizing Routine -- continued...

1. (See v.) None.

2. (See v.) None.

6. (See viii. a.) Raise 4 to minimum, for 70 students. Costs is 2.7k. Enter in cumulative sum.

7. (See ix.) Raise 5 to minimum. Cost is 345.6k. Enter in cumulative sum.

8. (See above) Close school 3.

9. (See above) Cumulative sume is 24k + 4k + 18k + 2.7k + 345.6k = 394.3k.

D. Optimizing Routine

The relevant data in this example are as follows:

| | School Number | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| viii. | Enrollment | 1500 | 1900 | 100 | 110 | 2500 |
| xi. | (Map) | | | | | |
| v. | Values, Actual or Potential | 57.5 | 45.5 | 19 | 34 | 21 |
| xi. | Regular Cost per Student per Year | 2.7k | 2.5k | 2.2k | 2.4k | 2.0k |
| xi. | Boarding Space | 60 | 80 | 10 | 20 | -- |
| ix. | School Satisfying Cost | 0 | 0 | 17k | 9.2k | 345.6k |

An additional input is the school system budget, which we set arbitrarily at $100k.

Following the flow chart for the optimizing routine, and using the above data, the following steps result:

1. (See v., xi., and xii.) The reasonable transfers are: 3 to 4; 3 to 2; 4 to 2; 4 to 1; and 2 to 1.
2. (See v. and xi.) Taking gains in value divided by increases in per-student cost gives c-e index.
3. (See ix.) Schools 3, 4, and 5.
4. (See v. and ix.) Taking potential values divided by costs to raise to minimum gives the c-e index.

Results thus far may be tabulated as follows:

| Option No. | Option | C-E Index |
|---|---|---|
| 1. | Transfer from 3 to 4 | 15/(0.2k) = 75 |
| 2. | " " 3 " 2 | 26.5/(0.3k) = 88 |
| 3. | " " 4 " 2 | 11.5/(0.1k) = 115 |
| 4. | " " 4 " 1 | 23.5/(0.3k) = 78 |
| 5. | " " 2 " 1 | 12/(0.2k) = 60 |
| 6. | Raise 3 to minimum | 19/( 17k) = 1.1 |
| 7. | " 4 " " | 34/(9.2k) = 3.7 |
| 8. | " 5 " " | 21/(345.6k) = 0.06 |

5. (See chart) Order of considering options is 3, 2, 4, 1, 5, 7, 6, and 8.
6. (See viii., xi., and chart) Attempting to implement options successively in order of decreasing cost-effectivenss yields the following series:

| Option No. | Effect | Enrollment / Boarding Space } Matrix | Cost |
|---|---|---|---|
| | viii. | 1500, 1900, 100, 110 | |
| | xi. | 60, 80, 10, 20 | |
| 3. | Tranfer 80 pupils from 4 to 2 | 1500, 1980, 100, 30<br>60, 0, 10, 100 | 80(0.1k) = 8k |
| 2. | Impossible | | |
| 4. | Transfer 30 pupils from 4 to 1 | 1530, 1980, 100, 0<br>30, 0, 10, 130 | 30(0.3k) = 9k |
| 1. | Transfer 100 pupils from 3 to 4 | 1530, 1980, 0 100<br>30, 0, 110, 30 | 100(0.2k) = 20k |
| 5. | Transfer 30 pupils from 2 to 1 | 1560, 1950, 0, 100<br>0, 30, 110, 30 | 30(0.2k) = 6k |
| 2. | Impossible | | |
| 7. | Raise 4 to minimum | | 9.2k |
| 6. | Close school 3 | 1560, 1950, ---, 100<br>0, 30, ---, 30 | |
| | | | SUBTOTAL = 52.2k |
| 8. | Raise 5 partly to minimum | | 100k - 52.2k = 47.8k |
| | | | TOTAL = 100k |

## Chapter X

### Examples of General Model Use

This chapter takes 3 kinds of problematic situations and through the use of hypothetical information demonstrates how the models described above can be used to aid the decision-maker. Other uses will most certainly be found. It is hoped that these examples will aid the manager in putting the models to use and will suggest further uses to him

The firxt example deals with population change for a given reservation and its impact on enrollment and school personnel, facilities, and equipment. Example two involves economic change and the Economic Projection Model's impact on BIA schools. And the final example shows how the costs for an experimental program in the use of educational television might be determined using the models.

### Population Changes and BIA Schools

Changes in the number of people served by an educational system, probably more than any other types of changes, have pervasive consequences for all aspects of the educational system. The present section presents a typical scenario of population change and shows how different BIA models may be applied to deal with the consequences of such change. Both the scenario and the model application are hypothetical, that is, the problem is not a real one and the models were not actually applied for problem solution. Nevertheless, both the scenario and the model applications are realistic, and the application of computer programmed versions of the models to similar problems will yeild comparable information.

### The Change Scenario

Let us suppose that the 1970 U.S. Census records show a number of changes in the demographic characteristics of the Indian population of a certain area. Because of better education in the previous decades, Indian males between the ages of 15 and 30 have outmigrated from the reservation in increasing numbers. At the same time, those who have remained on the reservation have tended to marry at a lower average age. Hygiene and health conditions in the area and, particularly, the care conditions for very young children have improved somewhat. Finally, because of the presence of a family planning service in the area and because some young married couples have begun to value the economic and social benefits of smaller families, age cohort feasibility has declined, particularly among the younger age groups. All these changes are occurring for a population in which members of the post-war "baby boom" are reaching marriageable age.

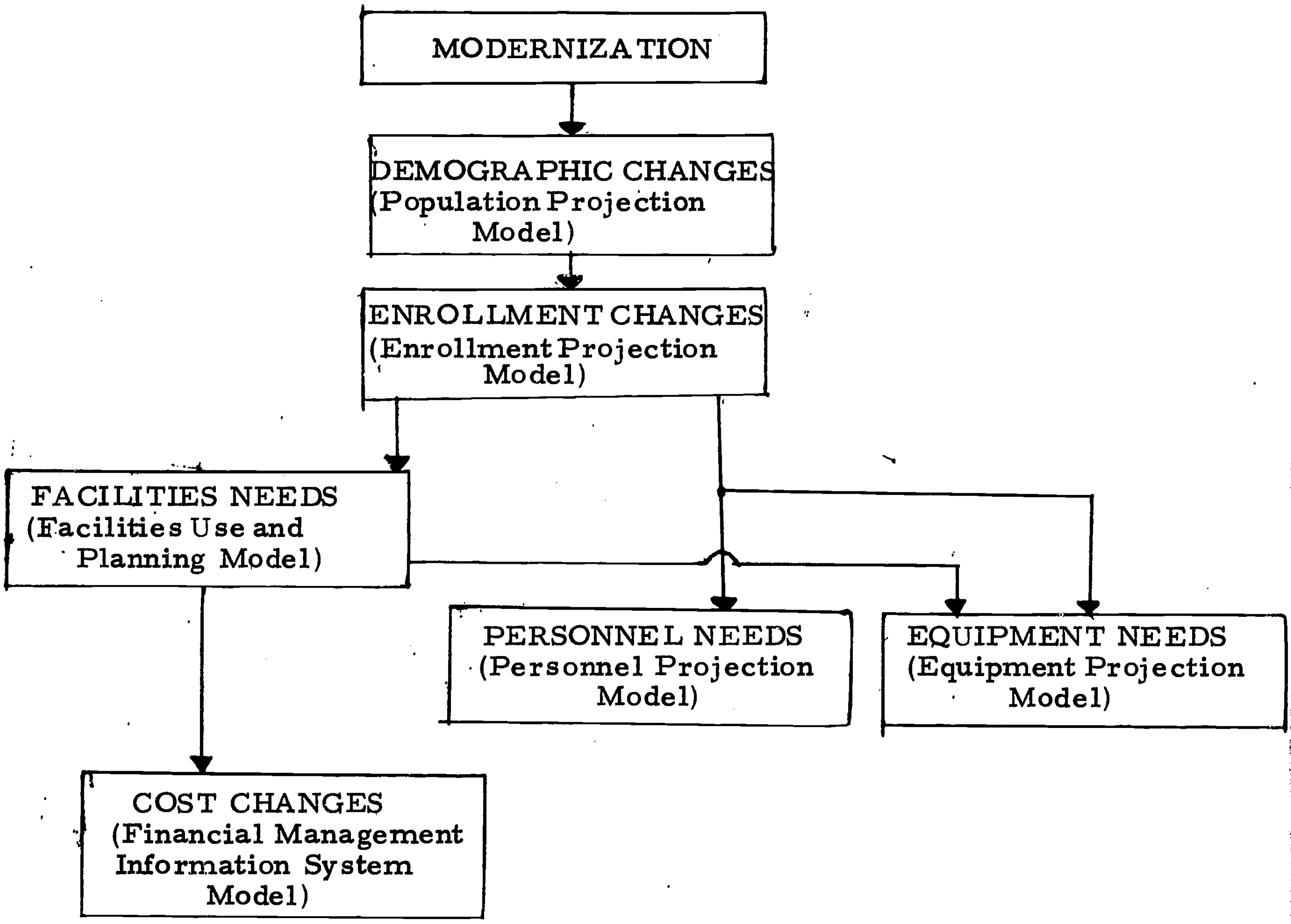
All of the demographic changes mentioned are a result of what may be loosely termed "modernization. They represent a realistic situation in that when modernization occurs, changes do not take place merely in one characteristic of a situation. Instead, we are likely to find that the changes in a number of interrelated characteristics of demography are caused by prior interdependent changes in technology, education and values. Demographic changes thus represent a quantitative summary of the effects of modernization in much the same way that economic market data quantitatively describes the results of interactions which involve social process.

Population Change and the BIA Models

In order to ascertain the long-range effects of modernization on the educational system, it is only necessary to have accurate information about the demographic characteristics of the population, not about the antecedent causes of such characteristics. Population change will affect the educational system primarily by inducing changes in numbers of Indian children of school age. School age population changes will in turn affect the needs for facilities, personnel and equipment in the school system. These changes will each be associated with changes in cost of school system operation.

Thus, evaluating the consequences of population changes due to modernization involves parallel and sequential application of certain BIA models. The Population Projection Model must be used to determine effects of modernization for future years. The Enrollment Projection

Model must then translate these changes into size of school age population by grade for future years. Changes in enrollment will be the basis for calculation by the Facilities Use and Planning Model of additional classroom and facilities needs. The Personnel Projection and Equipment Projection Models must be used to determine changes in these needs due to changes in enrollment and associated changes in facilities. Finally, the FMIS Model calculates future required resources on the basis of changes in the school system dictated by population change. The process of modernization, its consequences and BIA model applications may be flow charted as follows:



Application of the Models

The scenario described aboe would require exact specification in terms of inputs required by the Population Projection Model.

Specific inputs requiring modification include:

1. Age-specific migration rates (especially for males between ages 15 and 30)
2. Age-specific fertility rates (especially among females between ages 15 and 30)
3. Age-specific death rates
4. Infant-survival coefficient.
5. Fertility decline coefficient.
6. Initial population distribution (reflecting "baby boom" individuals reaching marriageable age).

Let us assume that calculations performed by the Population Projection Model produce the following population distribution for the ensuing five year period, 1971-1976:

| Age Group | Projected Population | Previous Estimate | Difference |
|---|---|---|---|
| 0-4 | 1200 | 1000 | 200 |
| 5-9 | 1100 | 1000 | 100 |
| 10-14 | 1000 | 950 | 50 |
| 15-20 | 1000 | 950 | 50 |

The Enrollment Projection Model then takes this information and estimates the one-year interval age distribution of children of school age as inputs and computes the estimated school enrollment in each class for a year (this example will deal with only one year of projected changes though the models are capable of projecting for as many years as is desired). Thus, for the 1971-1972 school years, enrollment by grade might be as follows:

| Grade | Projected Enrollment | Previous Estimate | Difference |
|---|---|---|---|
| K | 240 | 200 | 40 |
| 1 | 260 | 240 | 20 |
| 2 | 240 | 220 | 20 |
| 3 | 220 | 200 | 20 |
| 4 | 200 | 180 | 20 |
| 5 | 180 | 160 | 20 |
| 6 | 220 | 210 | 10 |
| 7 | 210 | 200 | 10 |
| 8 | 200 | 180 | 10 |
| 9 | 200 | 180 | 10 |
| 10 | 170 | 150 | 10 |
| 11 | 200 | 190 | 10 |
| 12 | 180 | 180 | 0 |

This information would be used by the Facilities, Personnel and Equipment Projection Models along with other inputs to provide projection of the following types:

1. Additional Facilities Needed

| | Number of Rooms Needed | Estimated Cost |
|---|---|---|
| Classrooms, K-6 | 5 | $125,000 |
| Classrooms, 6-12 | 2 | $ 40,000 |
| Etc. | | |

With appropriate policy decisions, the facilities Use and Planning Model would indicate the need for additional facilities and how they should be grouped.

2. Additional Personnel Needed

| Job Category | Number Needed | Cost |
|---|---|---|
| Kindergarten Teachers | 2 | $13,500 |
| 1 - 6 Grade Teachers | 4 | $28,000 |
| 7 - 12 Grade Teachers | 2 | $15,000 |
| Etc. | | |

3. Additional Equipment Needed

| Equipment Type | Number Needed | Cost |
|---|---|---|
| School Buses | 2 | $10,200 |
| Movie Projectors | 1 | $ 350 |

The costs associated with these changes, along with enrollment projections (provided as an output of the Facilities Use and Planning Model), serve as input to the Finance Management Information System Model, which then calculates the total costs associated with the changes due to changes in population These additional costs might look like this:

| Budget Category | Amount |
|---|---|
| Capital Expenditures | $65,000 |
| Personnel | $80,000 |
| Equipment | $10,550 |
| Operating Expenses | $10,000 |
| Total | $165,550 |

## Discussion and Conclusions

The present scenario analysis shows that with the proper specification of required inputs the models are capable of generating detailed information (as accurate as inputs) about educational needs. Use of the models in dealing with such problems has obvious benefits to the BIA in terms of planning for change and improving effectiveness of resource allocation. Specifically, facilities, personnel and equipment needs are known, and these needs can thus be better anticipated.

Though the present discussion has been based upon a specific situation, the method of use detailed would not change substantially for examination of any situation related to population dynamics. It may be concluded that the BIA models have strong interfaces which permit coordinated use of them in analyzing the educational system needs which results from demographic change.

## Economic Change and BIA Schools

### The Change Scenario

When economic change comes to an Indian area, it tends to cause a change in the density gradient of population in the area. This phenomenon is directly analogous to the national patterns of the past 100 years in the United States as a whole. Two major components of the national migration pattern have been movement from rural areas to urban areas, and movement from predominantly rural South to the urban, industrialized North. Associated with these patterns of migration have been overall increases in both rural and urban population. In the case of Indian areas, we may well expect that at least over time, location of industry will act as a magnet, drawing workers and their families closer to jobs, and thus increasing concentrations of population.

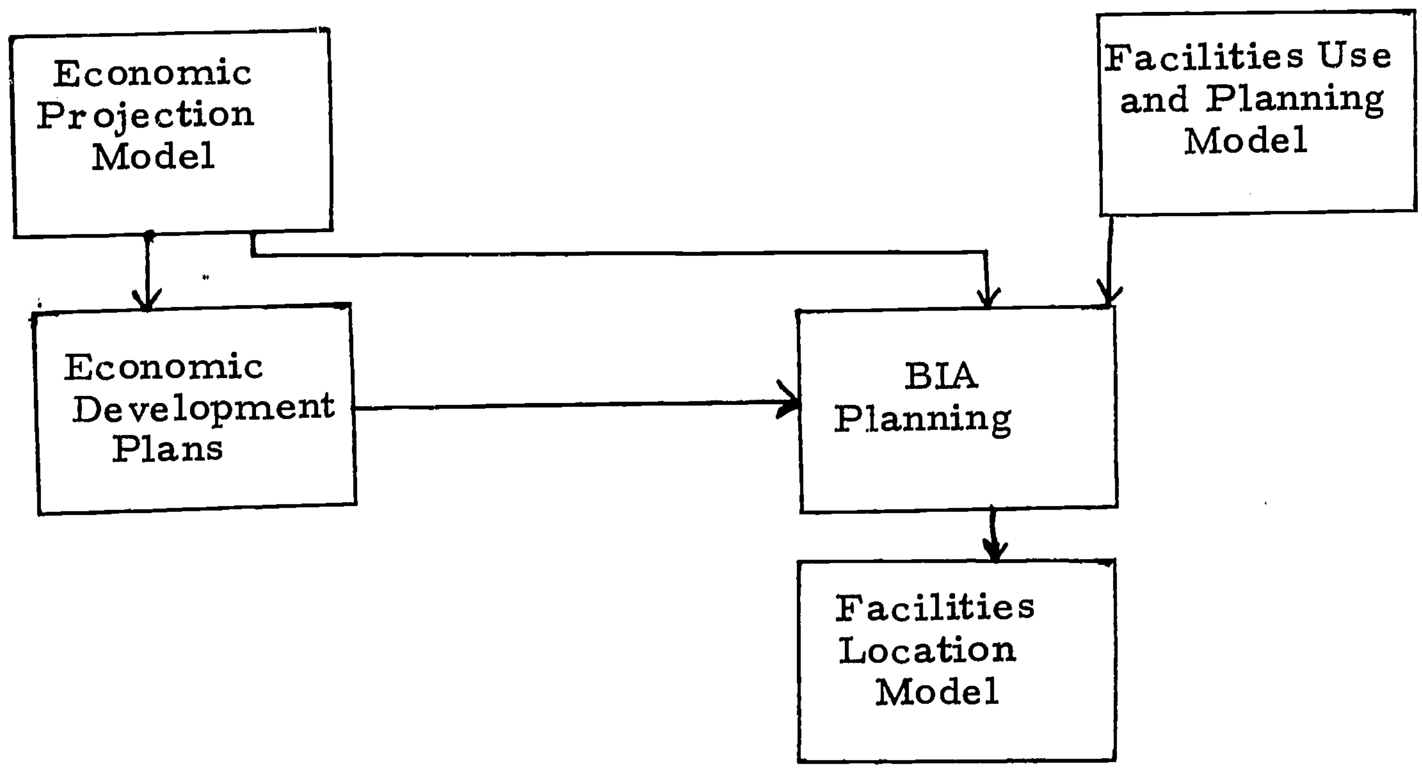
The present scenario assumes that economic change comes to an area in the form of an electronics company (Telectracomp, Inc.) which produces small, light-weight electronic components for use in computers and communication systems. The company will employ 100 Indian workers as well as 25 Indian foremen and managers and 25 non-Indian managers. The company is not restricted by locational requirements, since its production does not depend on natural resources and its output is easily transportable. Negotiations are presently under way between Telectracomp, the BIA, and the tribal council to find a suitable place for the firm's location. Telectracomp is interested in locating in an area close to a present concentration of population, but is willing to let the BIA and tribal council have a large say in site location

At the same time, a second company Acme Quarry and Gravel, has expressed an interest in locating in the area. The company would employ 30 Indians and locate near an adequate source of quarry sandstone. However, at the present stage of planning, no commitments have been made by the company and there have been no specific site suggestions.

BIA economic planning officials and tribal councilmen have decided to establish a one mile square industrial zone two miles outside of the principle town of Council Rock (population, 1,250), and have asked Telectracomp to locate in this area. School administrators have been informed of this decision and have also been briefed on the present status of negotiations between Acme and Indian area representatives.

## Economic Change and BIA Models

Since location of industry affects concentrations of population, the occurrences discussed above will have consequences for the location of schools in the area. Other information which serves as an input to locational decision is the additional facilities required in the area due to population changes. The analytical sequence of information and model use related to the problem of school locations may be depicted as follows:




## Application of the Models

The situation described above dictates use of BIA models in the following manner:

1) The specific location of Telectracomp, along with the company's pattern of Indian employment, serve as one input to the Facilities Location Model.

2) The Reservation Location Development Map and the specific Industry Location Desirability Map for the stone and clay quarrying and mining industry type--both outputs of the Economic Projection Model--provide additional locational information for the Facilities Location Model.

3) The Facilities Use and Planning Model details the number of additional classrooms and other facilities needed in the Indian area.

4) The Facilities Location Model provides a basis for BIA decision-making on the above information.

Sample outputs of the Economic Projection Model are provided in Chapter IV, p. ). The exact planned location of Telectracomp is given on the first map.

Let us assume that population and enrollment changes have been projected and that increases over the next five years by grade are as follows:

| Grade | Enrollment Increase |
|---|---|
| K | 100 |
| 1 | 80 |
| 2 | 80 |
| 3 | 80 |
| 4 | 80 |
| 5 | 80 |
| 6 | 70 |
| 7 | 70 |
| 8 | 70 |
| 9 | 70 |
| 10 | 70 |
| 11 | 70 |
| 12 | 60 |
| Total | 980 |

The agency has specified as input to the Facilities Use and Planning Model that any new schools constructed be designed as K-6 and 7-12 grade facilities. The model, operating on this data and other specified inputs, projects needed facilities over and above present facilities as follows:

| Type of School | Number of Regular Classrooms |
|---|---|
| K-6 | 24 |
| 7-12 | 15 |

Proper use of the Facilities Location Model requires certain manipulations of data before input. First, all information from the Economic Projection Model and information about company location plans must be combined into one statement of development probability. Thus, the Economic Development Projection Map must be modified to reflect a much higher incidence of development in the industrial park where Telectracomp is to locate and a slightly higher development possibility where sand quarry is feasible.

Second, aside from the other, more informational, input requirements for the Facilities Location Model, it is necessary for school planners to propose various alternative school location plans which can be evaluated by the model. These plans can be developed by both changing uses of present facilities and by proposing new facilities of various types and uses.

Assuming that these inputs are fulfilled by specification of the economic grid and six alternative location plans, the Facilities Location Model will compute a wide range of information about the plans (see Output, Chapter V, p. ). Comparative information concerning mean distance to school is as follows:

| Plan | Present Population Mean Distance | Rank | Projected Population Mean Distance | Rank |
|---|---|---|---|---|
| 1 | 3.7 | 1 | 4.17 | 4 |
| * 2 | 4.28 | 3 | 3.21 | 2 |
| 3 | 3.9 | 2 | 3.19 | 1 |
| 4 | 7.54 | 5 | 7.87 | 5 |
| 5 | 8.09 | 6 | 8.12 | 6 |
| 6 | 6.96 | 4 | 3.86 | 3 |

The plan marked by an asterisk was specifically designed to accommodate growth near the proposed industrial park.

Since there are no tremendous differences between the first three plans in terms of distance, it is possible to choose freely among them according to other criteria. It is thus likely that the second alternative plan would be chosen, since it is most favorable to economic development. If results had indicated that none of the plans efficiently minimized distance while encouraging economic development, it would have been possible to modify the more efficient plans and propose a second series of alternatives to be evaluated by the model. This process could be repeated until an acceptable solution was found.

## Discussion

The scenario of economic development is a fairly complicated one which involves different stages of negotiations for two companies. None of the models makes any attempt to quantify this information. Instead, it is the task of the user to summarize this information in one chart of grid square development information. Similarly, the output from the Facilities Use and Planning Model does not provide direct input for the School Location Model. Its output instead provides the information necessary to construct alternative plans which can be evaluated by the Facilities Location Model

Thus, the scenario shows that effective use of the models requires intermediate planning and policy development by the BIA. The models do not merely crank out hard and fast best solutions, but allow the planner to take an active role in developing solutions which can be much more responsive to non-quantifiable solutions than could any purely prescriptive model. While the scenario indicates the need for this human participation in planning, it shows at the same time that the BIA models provide useful and detailed information through meaningful integration of policy and previous information which could not be easily derived without use of the models.

## New Programs and the Models

### The Scenario

The Bureau of Indian Affairs is applying for a grant to start a pilot program of intensive educational television in one Indian agency. The pilot program is to include all grade levels, except kindergarten, but intensive use of EdTV is to begin at grade 7. The effort will be directed toward supplementation and improvement of science, math, and social studies curricula. All technical staff and equipment for the television station itself will be provided by an interested television network. Other staff and needed equipment will be provided by the BIA, but additional costs due to these needs will be met for the first five years under the terms of the grant. In order to obtain the grant, the BIA must submit a proposal delineating pilot program objectives, structure and planned content, and must specify all funds needed for the five year operation of the pilot program, exclusive of television station and technical staff costs.

The BIA plans a curriculum which takes the following general form:

| Grade | Course | No. Hours/Week |
|---|---|---|
| 1-3 | General Science (physical)<br>Cross-cultural Studies | 1 hr. every other week<br>1 hr. every other week |
| 4-6 | Mathematics<br>General Science (life)<br>Social Studies (cultural history) | 1 hr. every other week<br>1 hr. every other week<br>1 hr. every other week |
| 5 | Health and Personal Education | 1 hr. every other week |
| 7-9 | General Science<br>Social Studies (world history/ American history/Indian history) | 1 hr./week<br>1 hr./week |
| 9 | Math (algebra) | 1 hr./week |
| 10 | Social Studies (psychology)<br>Science (biology) | 3 hrs./week<br>2 hrs./week |
| 11 | Social Studies (gov. & sociology)<br>Science (chemistry) | 3 hrs./week<br>1 hr./week |
| 12 | Social Studies (current issues)<br>Science (physics)<br>Personal Education (guidance) | 3 hrs./week<br>1 hr./week<br>1 hr. every other week |

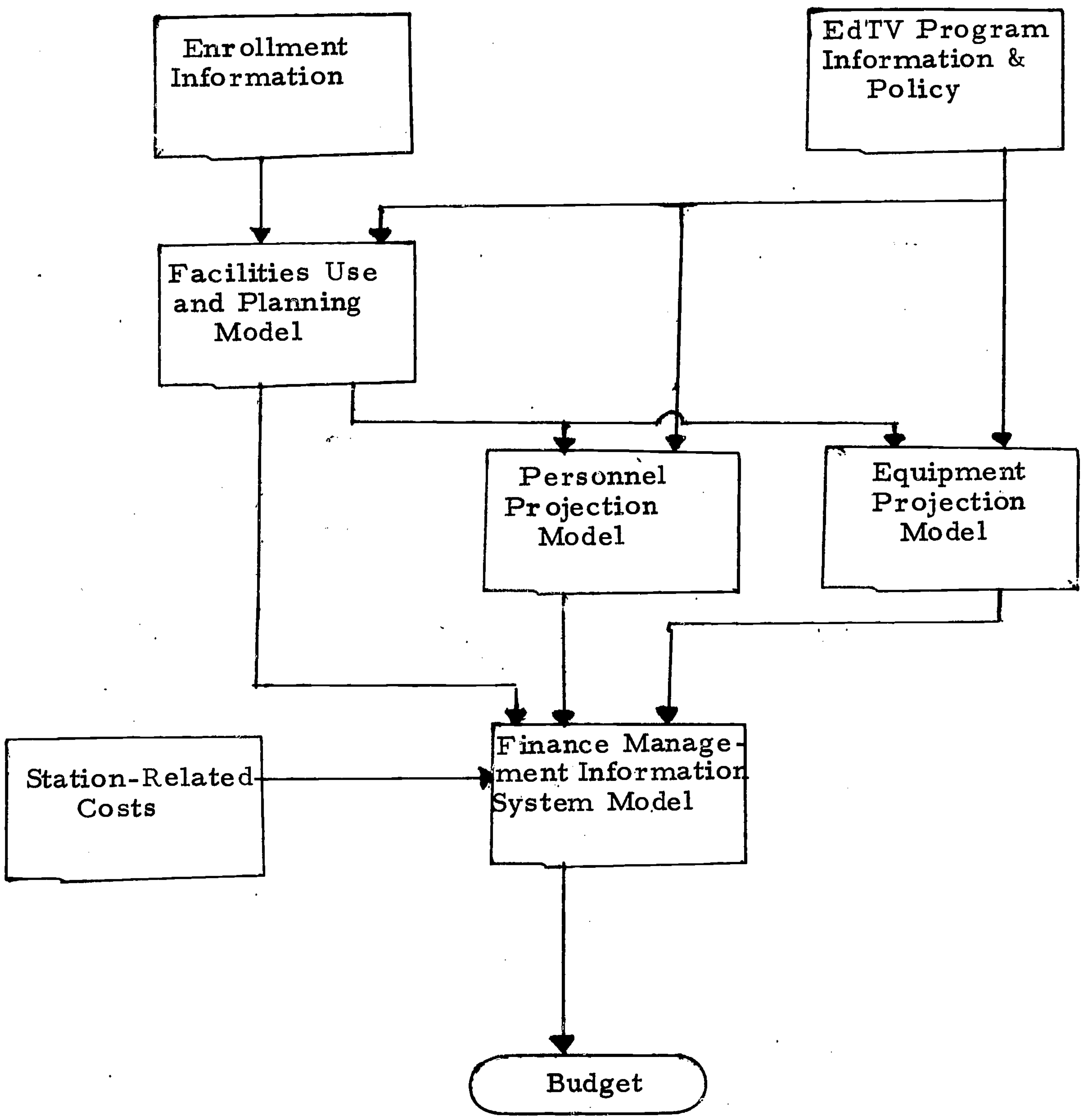
The curriculum is designed so that courses for more than one grade are of an "enrichment" nature and can be given on a rotating basis, the same course being given to all grades for a given year.

## Educational Television and the BIA Models

Obtaining the grant requires development of specific cost information by the BIA. Once the curriculum and program structure have been specified, the general requirements for school-related staff and equipment and station-related non-technical (i.e., teaching, production and administration) staff will become more apparent. Though station staff represents a specific case for which needs and costs will have to be developed separately, school-related staff and equipment needs and cost can be determined by application of the Personnel and Equipment Projection Models to general policy requirements.

Finally, the Finance Management Information System Model will combine the costs associated with changes in facilities, personnel, and equipment into a yearly itemized budget for the five years of the pilot program.

The conceptual flow of information, policy and model application may be depicted as follows:



## Application of the Models

Let us assume the following: 1) that the curriculum and program structure have been designed in such a manner that one educational television classroom is needed for each school; 2) that the number of televisions needed for each classroom is a function of the maximum number of students who will be viewing a program at one time; 3) that one technical and administrative staff member will be required for each television classroom; and finally, 4) that for each television course offered in a school, one teacher will be required for a given number of students, to provide instruction coordinated with the educational television course. Each teacher of this type would be drawn from present teaching staff and would receive additional compensation for time spent planning coordinated instruction.

These assumptions will be more explicitly developed by following the model application sequence for one school for one year, since the process will be the same for all schools and years.

Enrollment for the Mesa Verde Elementary School is projected as follows:

| Grade | Projected Enrollment (1971-72) |
|---|---|
| 1 | 60 |
| 2 | 70 |
| 3 | 60 |
| 4 | 55 |
| 5 | 60 |
| 6 | 60 |
| Total | 365 |

The Personnel Projection Model uses enrollment data, policy statements about personnel/requirements ratios, and cost per staff member to compute the total number of personnel of various categories needed, and the total costs associated with use of these personnel in the pilot program. These policy statements might take the following form:

| Position | Grade | Course | Requirements |
|---|---|---|---|
| 1 | 1-3 | General Science | (No. staff/no. 1st graders + no. 2nd graders + no. 3rd graders) = 1/25 |
| 2 | 1-3 | Cross-cultural Studies | (Same as above) |
| 3 | 4-6 | Mathematics | (No. staff/no. 4th graders + no. 5th graders + no. 6th graders) = 1/25 |
| 4 | 4-6 | General Science | (Same as above) |
| 5 | 4-6 | Social Studies | (Same as above) |
| 6 | 5 | Health & Personal Ed. | (No. staff/no. 5th graders) = 1/15 |

Cost associated with each staff member would be $250/year.

Calculations on the basis of policy and the enrollment data provided earlier would yield the following results:

Mesa Verde Elementary School - Educational Television Pilot Program

| Position | Number of Staff Needed | Cost |
|---|---|---|
| 1 | 6 | $1,500 |
| 2 | 6 | 1,500 |
| 3 | 6 | 1,500 |
| 4 | 4 | 1,000 |
| 5 | 6 | 1,500 |
| 6 | 6 | 1,500 |
| Total | 34 | $8,500 |

Policy statements about equipment needs would be based upon the total number of students who would be using the television classroom at one time. An adequate ratio of televisions to students might be set up as 1/90. This policy would be programmed in the Equipment Projection Model's FACIL function (Chap. Vii, p.   ) and equipment needs would be computed by the model to be:

Mesa Verde Elementary School

| Type of Equipment | Number Needed | Cost |
|---|---|---|
| Television Sets | 4 | $600 |

The FMIS Model would take as inputs all costs and their respective cost codes and develop a budget which might take much the following form for all schools in the Program:

| Educational Television Pilot Program Projected Budget | |
|---|---|
| Cost Category | Amount |
| Personnel - Total | $80,000 |
| Category 1 = 12,750 | |
| ---------- | |
| ---------- | |
| Category 16 = 8,000 | |
| Equipment - Total | 27,000 |
| Category 1 | 22,000 |
| ---------- | |
| ---------- | |
| Category 8 | 500 |
| GRAND TOTAL | $129,500 |

## Discussion

The BIA models may be fruitfully used in the present scenario to systematically determine the specific needs for personnel and equipment and their costs if a pilot program of educational television is implemented in a specific Indian area. The scenario illustrating this type of model use is a specific one, but the problem of investigating policy implications is much more general. Though in this example, policy only has implications for personnel and equipment, the same process of use applies when the impact of change is either broader or more restricted.

Use of the BIA models in this type of situation has at least four major benefits.

1) Use of the models requires concrete specification of policy, thus encouraging more detailed development and understanding of policy before it is implemented.
2) Concrete specification provides the basis for accurate and detailed cost estimates for any number of schools and situations.
3) Use of the models takes into account other information besides policy (e.g., enrollment) and thus provides an estimation of

policy costs for a series of projected years. This characteristic is particularly important since start-up and ongoing costs can be accounted for separately.

4) Finally, use of the models insures equal treatment of all schools or situations, or at least makes explicit the differences in treatment, when such differences become necessary because of variations in needs.

## Chapter XI

## Overall Selection of Most Cost-Effective Programs

### Introduction

A variety of educational, economic, socio-cultural and other programs which could be implemented by the Bureau of Indian Affairs have been presented in Volume III of this report. It is obviously well beyond the budgetary means of the Bureau to invest in all of these programs. Thus, it was necessary to develop a method by which to select a mix of programs for a given level of spending, such that the desired effect on the problems confronting the BIA would be maximized. Such a mix has come to be known as the most "cost-effective" solution.

A Program Mix Cost-Effectiveness Model has been developed for determining this solution. This section presents the model, describes how it works, and gives the results of five different runs of the Model on the programs previously generated. Each run represents a different point of view (i.e., student, teacher, administrator, parent, and consultant) as to the priority of problems facing the BIA. For each point of view, the most cost-effective mix of programs is given for four levels of BIA spending: $0 additional budget; $10,000,000 additional budget; $50,000,000 additional budget; and $100,000,000 additional budget.

### The Program Mix Cost-Effectiveness Model

The determination of cost-effectiveness for a program as yet untried in BIA schools requires the determination of the two components of the term "cost" and "effectiveness." Costs have already been estimated in Volume III, and will not be dealt with at this point.

The concept of "effectiveness," however, bears more discussion, as it does not have the same sort of common-sense meaning that "cost" has for most people. When we speak of effectiveness in terms of future events, we would do well to consider several points.

First, we must ask: "effectiveness with regard to what?", for the word "effectiveness" implicitly assumes that some goal or need is being served according to some measure or criterion. Second, we must determine how relevant a program is to the attainment of the specified goal or need, for a program which might be very effective in dealing with a problem such as achievement lag, might be irrelevant to that problem simply because it did not affect a substantial portion of the population. Third, since the programs which must be evaluated have not been tried in the BIA school environment, we must determine how much confidence there is that the program will actually work. Finally, there is the basic effect of the program, that is, the size or degree of change.

Consideration of these factors led to the following design of the Program Mix Cost-Effectiveness Model:*

1. Programs are evaluated in terms of their effectiveness in dealing with nineteen mutually exclusive problem areas in which the BIA schools can have an impact. These problem areas are:

    1. Instruction and Classroom Process
    2. Student Motivation
    3. Student Academic Achievement/Success
    4. Teacher Role
    5. Curriculum
    6. Student Inhibitions
    7. Boarding School Life
    8. Language Barrier
    9. Job Opportunities
    10. Further Educational Opportunities
    11. Guidance and Counseling
    12. School Administration
    13. Innovation
    14. Resource Allocation
    15. Parental Involvement
    16. Community Organization
    17. Lack of Alternative Success Models
    18. Cultural Isolation
    19. Geographic Isolation

2. Since not all problem areas are of equal importance and since limited resources must be allocated to deal with all problems, 100 IMPORT points are allocated among the problem areas by the user according to his estimation of their importance.

3. For each program, a rating of RELEVANCE to each problem is given on a zero to one point scale by the user.

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* Instructions for using the model and a computation worksheet are included in Appendix .

In order to estimate relevance, first determine what percentage of the school population is affected by the program. For example, if only high school students are affected, assume R = 0.5. If only those students planning to go to college are affected, assume the national average of 0.3. If only students of high school science are affected, assume some two-thirds of the 50 percent in high school, or about 0.3. If a pervasive aspect, such as motivation or language skills, is affected, assume .8 or .9 (80 or 90 percent) relevance.

4. The user estimates the EFFECTIVENESS of each program for each of the nineteen problem areas on a zero to one point scale. Program effectiveness may be estimated on the basis of what percentage of the target group responds according to program goals. Thus, if a reading curriculum program is intended to raise reading achievement scores two years in one school year, and only half the students are estimated to achieve this goal, then the program's effectiveness is 0.5.

5. A measure of CONFIDENCE in the success of each program is given on the following basis:

0.8 - 1.0 - proven in the BIA
0.6 - 0.8 - proven in a similar population
0.4 - 0.6 - proven in a dissimilar population
0.2 - 0.4 - theoretical basis
0.0 - 0.2 - favorable opinion

6. For each program, the cost-effectiveness may then be computed as follows:

$$\text{Cost-Effectiveness}_J = \frac{\left[\sum_{I=1}^{19} (\text{IMPORT}_I) \times (\text{RELEVANCE}_{I,J}) \times (\text{EFFECTIVENESS}_{I,J})\right] \times \left[\text{CONFIDENCE}_J\right]}{\text{COST}_J}$$

where I = number of the problem area, and
J = number of the program

7. When cost-effectiveness has been determined for all programs under consideration, the programs may be re-ordered on the basis of cost-effectiveness. When a budgetary LIMIT is imposed, it is possible to start with the most cost-effective program and continue choosing the next most cost-effective program, aggregating COSTs of programs until the LIMIT is reached. This method provides the most cost-effective set of programs for the given budget.

8. Two considerations may warrant modification of this list of programs.

A. It is possible for all the most cost-effective programs to be concentrated in relevance and effect on a few problem areas. The user may therefore wish to compute the sum of non-IMPORT-weighted RELEVANCE-EFFECTIVENESS for all programs chosen for each problem area to see if the figures are roughly proportional to the IMPORT weights. Optimally, the ratio --

$$\text{TUNE}_I = \text{IMPORT}_I \Bigg/ \left[ \frac{\sum_{J=1}^{N} (\text{RELEVANCE}_{I,J}) \times (\text{EFFECTIVENESS}_{I,J})}{\sum_{I=1}^{19} \sum_{J=1}^{N} (\text{RELEVANCE}_{I,J}) \times (\text{EFFECTIVENESS}_{I,J})} \right]$$

where I = problem area number, and
J = program chosen number, and
N = total number of programs chosen

-- should equal 1.0. Should there be wide deviations from this situation, the user may wish to <u>unchoose</u> the least cost-effective programs which are relevant to a problem area, where $\text{TUNE}_I$ is greater than 1.0, and <u>choose</u> the next most cost-effective programs which have relevance in problem areas, where $\text{TUNE}_I$ is less than 1.0 -- always keeping the aggregate cost below the LIMIT.

B. It is also possible for highly cost-effective programs to be "linked" with less cost-effective programs in such a way that the two programs have an interactive effect, each by its presence increasing the cost-effectiveness of the others. Such might be the case with, for example, a program for research and development and a newsletter which could report the findings, so that they could be widely applied.

Thus, the user may wish to examine all combinations of two programs to subjectively estimate such linkages. Where he finds that a chosen program is linked with a non-chosen (i.e., low cost-effective) program, he may wish to substitute the previously unchosen program for the least cost-effective program previously chosen, while making sure that aggregate cost does not exceed the LIMIT.

## Cost-Effective Program Mixes: Results of Model Use

The model was run on one set of RELEVANCE, EFFECTIVENESS, and CONFIDENCE data for five different sets of IMPORT ratings representing students', teachers', administrators', parents', and the consultants' ratings of the various problem areas.*

Although some programs had substantially different cost-effectiveness ratings under the various IMPORT weighting systems, the majority of programs kept the same general rank of cost-effectiveness throughout.

Differences in cost-effectiveness between various programs were much more extreme. Aside from the programs with infinite cost-effectiveness (e.g., those with no major costs) and programs with .00 cost-effectiveness, programs ranged in cost-effectiveness from $0.03 \times 10^{-8}$ (multiple small day schools) to $916.933 \times 10^{-8}$ (biographical films on Indians). Programs with projected costs of greater than $15,000,000 tended not to be cost-effective, but otherwise there seems to be no strong correlation between cost of a program and its cost-effectiveness. For example, under the teacher IMPORT weighting system, both use of college facilities ($9,000) and short field trips ($960,000) ranked among the twenty-five most cost-effective programs.

The results of the five present runs of the models are given on the following pages. For each point of view, programs are listed in order of cost-effectiveness. Four spending cut-off points are drawn for each of the five points of view. The first budget limit of $0 additional spending includes the $0 cost programs, and is the same for all five points of view. The second budget limit is $10,000,000; the third, $50,000,000; and the fourth, $100,000,000.

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* These data are included in Appendix . . Where they were available, results of EDPLAN games were adapted as IMPORT weights.

INDEX OF RESULTS FOR THE FIVE RUNS OF THE PROGRAM MIX COST-EFFECTIVENESS MODEL

TABLE 11.0: . PROGRAM LIST

1. Contract Schools
2. Cash for Achievement
3. Curriculum Development
4. Tutoring of Infants
5. Seminar Groups
6. Students Rating Teacher
7. Work Week in Review
8. Role Switching
9. Intra-School Academic Competition
10. Cost-Effectiveness System
11. Classroom Teams
12. Upward Bound to High School
13. College Preparatory High School
14. College Preparatory Post High School
15. College System
16. Separate Sexes
17. Family Cottage Boarding
18. Indian Elite School
19. Work/Study Program
20. Master Tutors
21. Inter-School Academic Competitions
22. Indian Corps
23.
24. Instructional Structures
25. Evaluate ESL Programs
26. Master Linguist Tutor
27. Senior Language Teacher
28. Student Produced Films
29. Student Produced Texts
30. Intensive School Drama Program
31. Standardized Testing
32. Innovation Councils
33. Cross-Discipline Course
34. Flight Training
35. Ham Shacks
36. Elementary School Zoos
37. Improvisational Theatre Techniques
38. Information Exchange Newsletter
39. Long Summer Field Trips
40. Short Field Trips
41. Vocational Mobility
42. Heavy Construction Course
43. Mechanical Zoo
44. Technological Micro-Museums
45. Teacher Recruitment

PROGRAM LIST -- continued

46. On-Bus, On-Line Education
47. Pay Teachers Based on Achievement
48. Academic Awards
49. Sabbaticals for Teachers
50. Recruit Indian Teachers
51. Mobile School Helicopter
52. Mobile School Ship
53. Mobile School Truck
54. Team Learning
55. Increase Research and Development Sources
56. Improved Public Relations
57. Subscription to Journal
58. Indian Teachers Aides
59. Research and Development Sabbaticals
60. Incentives for Principal Performance
61. Teacher/Counselors
62. Pupil Exchange Foster Homes
63. Video Tape Classroom
64. Biographical Films on Indians
65. World of Work Films
66. Film and T.V. Analysis
67. Contract School
68. Parent Education in Evaluation
69. Parent School Orientation
70. Local School Boards
71. Master Teachers for Parents
72. Parent Orientation Film
73. Home Service Centers
74. Pre-College Work
75. College Scholarship
76. Loan Program
77. Income-Producing Projects
78. Local School Control of Budget
79. Research and Development Budget Times Four
80. Integrated BIA Schools
81. Social Studies Via Art and Folk Songs
82. Vouchers for Employment
83. Political Science Courses
84. Touring Success Models
85. Traveling Shows
86. Foster Homes Near Central Schools
87. Periodic Centralized Schools
88. Home Instruction by Siblings
89. Multiple Small Day Schools
90. Para-Professional Scholarship Grants
91. Storefront Computer Instruction
92. Eleventh Grade Educational Research
93. Orientation Centers

94. Distribution of Television Sets
95. Computerized Instruction
96. Homework Helper Program
97. High School Work/Study: Pupils Live On Own
98. Year End High School Conference
99. Public School Placement by Guidance
100. Parent Involvement Planning Model
101. Classroom Role Play
102. Indian Social Dynamics Study
103. Educational Board Game
104. Sociology and Language Arts Course
105. Game for High School Students
106. Folk School
107. Indian Free University
108. Greenhouse Construction
109. Language Teaching Machine
110. Community Planning New Schools
111. Facilities for Parental Involvement
112. Educational Exchange Program
113. Film Series
114. Library Combination
115. Printing Presses
116. Intensive Study Schools
117. Teacher Training Program
118. Teacher In-Service Training
119. Relate Language Instruction to Other Subjects
120. Student Participation in Educational Material Selection
121. Use of College Facilities
122. College Special Centers
123. Adult Illiteracy Sociology
124. Minority Sociology Course
125. Government-Tribe Sociology Course
126. Environmental Economics Course
127. Ethnic Differentiation Course
128. Land Use Course
129. Wales Minority Sociology Course
130. Junior High National Minority Sociology Course
131. Non-Self-Sufficient Economics Course
132. Sociology of Minority Education Course
133. Nations Within Nations Course
134. K-3 Language Arts Curriculum
135. 4-6 Language Arts
136. Junior High Language Arts Curriculum
137. Media and Communications Curriculum
138. K-3 Social Studies Curriculum
139. 4-6 Social Studies Curriculum
140. 7-12 Social Studies Curriculum
141. 7-9 Social Studies Curriculum
142. 10-12 Social Studies Curriculum
143. 1-3 Science Curriculum
144. 4-6 Science Curriculum
145. 7-9 Science Curriculum
146. 10-12 Science Curriculum

| Program Number | C-E (Student) | C-E (Teacher) | C-E (Admin.) | C-E (Parent) | C-E (Cons.) | COST |
|---|---|---|---|---|---|---|
| 1 | 4.0125 | 3.8603 | 2.9028 | 3.1863 | 3.6431 | 2233000 |
| 2 | 132.313 | 214.346 | 166.903 | 165.769 | 200.259 | 21162 |
| 3 | 4.1047 | 15.2169 | 3.2122 | 4.5831 | 5.11 | 3600000 |
| 4 | .2494 | .83976 | .64096 | .54217 | .8289 | 4150000 |
| 5 | 999.99999999 | 999.99999999 | 999.99999999 | 999.99999999 | 9999.999999999 | 0 |
| 6 | 999.99999999 | 999.99999999 | 999.99999999 | 999.99999999 | 9999.999999999 | 0 |
| 7 | 999.99999999 | 999.99999999 | 999.99999999 | 999.99999999 | 9999.999999999 | 0 |
| 8 | 999.99999999 | 999.99999999 | 999.99999999 | 999.99999999 | 9999.999999999 | 0 |
| 9 | 999.99999999 | 999.99999999 | 999.99999999 | 999.99999999 | 9999.999999999 | 0 |
| 10 | .0 | .65909 | 5.5625 | .0 | 1.56819 | 880000 |
| 11 | 30.2055 | 57.9544 | 32.99 | 46.9577 | 32.7818 | 153500 |
| 12 | 8.28131 | 8.77757 | 6.79626 | 8.79252 | 7.83551 | 535000 |
| 13 | 11.327 | 4.88274 | 4.7196 | 10.6395 | 6.32192 | 1373000 |
| 14 | 3.50588 | 1.85882 | 1.25882 | 2.39412 | 2.03529 | 1530000 |
| 15 | 3.84 | 5.68 | 4.48 | 5.32 | 5.2 | 1000000 |
| 16 | 999.99999999 | 999.99999999 | 999.99999999 | 999.99999999 | 9999.999999999 | 0 |
| 17 | .0549743 | .650057 | .465942 | .408857 | .466457 | 35000000 |
| 18 | 6.74 | 3.84 | 3.84 | 6.98 | 4.68 | 250000 |
| 19 | 4.13 | 2.4636 | 2.807 | 4.1598 | 4.32828 | 3229000 |
| 20 | 2.20618 | 4.51744 | 2.61015 | 2.34879 | 3.96291 | 2265000 |
| 21 | 14.5722 | 34.893 | 16.9786 | 1.73797 | 22.0588 | 37400 |
| 22 | 999.99999999 | 999.99999999 | 999.99999999 | 999.99999999 | 9999.999999999 | 0 |
| 23 | .0 | .0 | .0 | .0 | .0 | |
| 24 | 1.4104 | 1.66936 | 1.00809 | 1.35954 | 1.80809 | 865000 |
| 25 | 9.78044 | 3.69261 | 4.29142 | 6.48703 | 7.08403 | 400800 |
| 26 | 3.18519 | .748148 | .985185 | 1.5556 | 1.47407 | 2160000 |
| 27 | 6.18865 | 1.54716 | 1.81391 | 2.77422 | 2.72097 | 468600 |
| 28 | 1.47862 | 2.34345 | 2.03862 | 1.10621 | 2.98759 | 2900000 |
| 29 | 19.3429 | 2.77929 | 10.8429 | 2.40214 | 2.58429 | 280000 |
| 30 | 4.5 | 5.53252 | 3.34959 | 3.49503 | 4.84959 | 1230000 |
| 31 | 1.84615 | 1.28 | 3.81538 | 6.15385 | 17.8051 | 390000 |
| 32 | 12.1249 | 17.2982 | 9.21491 | 15.3582 | 25.1389 | 98970 |
| 33 | 24.1633 | 22.9717 | 15.4680 | 18.5767 | 23.6558 | 271900 |
| 34 | 2.62182 | 2.53818 | 2.05455 | 2.13091 | 2.88727 | 1100000 |
| 35 | 9.024 | 5.892 | 4.74 | 5.436 | 6.264 | 500000 |
| 36 | 2.4 | 5.15294 | 3.21882 | 3.12706 | 4.68706 | 850000 |
| 37 | 261.6 | 456.4 | 258. | 327. | 376.2 | 20000 |
| 38 | 234.667 | 459.378 | 327.822 | 227.779 | 379.022 | 22500 |
| 39 | 3.70147 | 2.11324 | 2.14853 | 2.58529 | 2.28971 | 1360000 |
| 40 | 18.9188 | 21.0656 | 1.30594 | 1.16063 | 18.5438 | 960000 |
| 41 | 100.8 | 93.52 | 86. | 118.88 | 88.48 | 100000 |
| 42 | 1.16519 | .984427 | .880611 | 1.12977 | 1.4229 | 6550000 |
| 43 | 3.56364 | 7.07879 | 3.2 | 2.61818 | 6.10909 | 165000 |
| 44 | .592 | .928 | .413333 | .290667 | .770667 | 1500000 |
| 45 | 2.65139 | 4.1176 | 3.11875 | 4.23673 | 3.43643 | 2619000 |
| 46 | 1.5871 | 1.5329 | 1.13806 | 1.2 | 1.28 | 6200000 |
| 47 | .672 | 2.624 | 1.28 | 1.79733 | 2.18133 | 2250000 |
| 48 | 26.1333 | 66.4 | 44.4444 | 17.3333 | 54.9333 | 90000 |
| 49 | .0 | .754526 | .282947 | .471579 | .660211 | 2375000 |
| 50 | 11.0798 | 30.9642 | 14.8717 | 8.08324 | 16.6659 | 432500 |
| 51 | .106333 | .091 | .04067 | .0733 | .08717 | 24000000 |
| 52 | .722 | .593 | .4315 | .3 | .586 | 10000000 |
| 53 | .15234 | .135319 | .105957 | .118298 | .150638 | 15100000 |
| 54 | 19.1822 | 49.0311 | 25.9733 | 27.1822 | 36.2133 | 450000 |
| 55 | 33.12 | 46.24 | 52.72 | 48.64 | 58.72 | 100000 |
| 56 | 8. | 10.4658 | 20.7671 | 12.8767 | 8.38356 | 146000 |
| 57 | 3.2 | 67.84 | 29.44 | 32. | 85.76 | 12500 |
| 58 | 1.48109 | 1.32035 | 1.16182 | 1.85099 | 1.60439 | 10900100 |
| 59 | 1.128 | 4.256 | 2.952 | 3.32 | 4.024 | 750000 |
| 60 | 6.667 | 6.1 | 8.21667 | 8.05 | 7.08333 | 1200000 |

TABLE 11.1

| Program Number | C-E (Student) | C-E (Teacher) | C-E (Admin.) | C-E (Parent) | C-E (Cons.) | COST |
|---|---|---|---|---|---|---|
| 61 | .39 | 1.26 | .68 | .41 | .778 | 6000000 |
| 62 | .812549 | .356418 | .242614 | .291765 | .347712 | 9562500 |
| 63 | .10667 | 1.29219 | .560762 | .579048 | 1.11543 | 5250000 |
| 64 | 462.533 | 910.933 | 468.523 | 26.133 | 728. | 7500 |
| 65 | 36.2 | 22.1 | 18.2667 | 24.4333 | 18.5667 | 480000 |
| 66 | 4.82162 | 3.67568 | 2.55135 | 2.10811 | 3.94595 | 740000 |
| 67 | 4.38667 | 7.78667 | 1.41422 | 6.73778 | 1.09867 | 675000 |
| 68 | .410256 | .205128 | .410256 | 1.02564 | .820513 | 390000 |
| 69 | .379447 | .189723 | .379447 | .948617 | .758893 | 759000 |
| 70 | .742857 | 3.44 | 3.65143 | .514286 | 3.21143 | 1400000 |
| 71 | .157193 | .0786 | .157193 | .392982 | .314386 | 1425000 |
| 72 | 7.2 | 3.6 | 7.2 | 18. | 14.4 | 35000 |
| 73 | 36.8846 | 27.4615 | 26.1827 | 44.4231 | 34.7308 | 104000 |
| 74 | 8.79521 | 4.22515 | 4.74251 | 11.4683 | 4.74251 | 835000 |
| 75 | 2.8125 | 2.86875 | 2.48625 | 3.8475 | 2.75625 | 2400000 |
| 76 | 7.47 | 2.445 | 3.075 | 9.835 | 3.075 | 1800000 |
| 77 | .854 | 1.295 | 1.981 | 2.135 | 2.163 | 1000000 |
| 78 | 1.6 | 9.12 | 108. | 4. | 29.76 | 100000 |
| 79 | 30.416 | 4.1616 | 3.5904 | 3.4032 | 3.3664 | 5000000 |
| 80 | 1.02568 | .475 | .260842 | .343368 | .412632 | 9500000 |
| 81 | 5.49231 | 11.9179 | 6.78462 | 5.52821 | 10.159 | 585000 |
| 82 | .139522 | .038756 | .077512 | .147273 | .116268 | 41800000 |
| 83 | 1.4 | 3.5 | 2.1 | 3.5 | 1.4 | 200000 |
| 84 | 12.572 | 13.104 | 7.532 | 5.32 | 13.664 | 250000 |
| 85 | 5.28696 | 1.78551 | 1.2058 | 3.03768 | 2.89855 | 690000 |
| 86 | 9.15692 | 3.49538 | 2.01846 | 3.10154 | 3.79077 | 975000 |
| 87 | .196 | .066445 | .076412 | .139535 | .126246 | 6020000 |
| 88 | 3.52 | 7.06783 | 4.28522 | 4.38261 | 4.66087 | 57500 |
| 89 | .08569 | .0659 | .03397 | .08366 | .08265 | 35500000 |
| 90 | 20.3774 | 9.4717 | 9.62264 | 23.9623 | 14.3962 | 212000 |
| 91 | .0794 | .0392 | .0784 | .196 | .156 | 306000 |
| 92 | .8095 | 1.50476 | .981 | 1.3238 | 1.28571 | 420000 |
| 93 | 7.13514 | 2.77477 | 1.95495 | 5.00901 | 4.64865 | 444000 |
| 94 | 98.8163 | 34.408 | 25.0408 | 33.3030 | 37.7143 | 98000 |
| 95 | 3.22917 | 6.45833 | 3.64583 | 6.5625 | 5.72917 | 240000 |
| 96 | 10.0571 | 14.9943 | 11.7943 | 13.8971 | 13.7143 | 700000 |
| 97 | 7.95789 | 5.01754 | 4.24561 | 5.97895 | 6.03509 | 570000 |
| 98 | 20.8696 | 32. | 13.2174 | 13.913 | 26.4348 | 69000 |
| 99 | 5.52212 | .637168 | .37699 | .0849558 | .361062 | 452000 |
| 100 | .4183 | .4183 | 1.98693 | 1.04575 | 1.2549 | 76500 |
| 101 | 33.5922 | 19.767 | 9.767 | 29.126 | 159.223 | 41200 |
| 102 | 1.412 | 5.504 | 2.344 | 3.876 | 3.46 | 2000000 |
| 103 | 6.667 | 3.333 | 6.667 | 16.667 | 13.33 | 18000 |
| 104 | 19.7486 | 7.54286 | 4.38857 | 5.07429 | 7.13143 | 175000 |
| 105 | 97.11 | 169.485 | 123.4 | 117.526 | 154. | 19400 |
| 106 | .288 | .213 | .1128 | .175484 | .175487 | 1436000 |
| 107 | .929 | .3097 | .387 | 1.1032 | .3871 | 620000 |
| 108 | .3808 | 2.464 | 1.31 | .224 | 1.9936 | 625000 |
| 109 | 12.73 | 10.8 | 8.50435 | 10.0957 | 11.8435 | 115000 |
| 110 | 999.999999 | 999.9999999 | 999.999999 | 999.999999 | 999.99999999 | 0 |
| 111 | .497778 | .248889 | .497778 | 1.2444 | .99556 | 900000 |
| 112 | 18.86 | 14.14 | 11.7 | 16.66 | 12.51 | 344000 |
| 113 | 16.9778 | 21.1333 | 10.1778 | 8.2 | 12.533 | 180000 |
| 114 | .97111 | 2.17778 | 1.30667 | 2.17778 | .87111 | 900000 |
| 115 | 7.2 | 4.56 | 5.088 | 9.264 | 6.192 | 750000 |
| 116 | 3.536 | 5.568 | 4.184 | 5.2 | 5.296 | 500000 |
| 117 | 2.844 | 4.267 | 3.0815 | 5.68889 | 4.0296 | 540000 |
| 118 | .0 | 6.72 | 2.52 | 4.2 | 5.88 | 300000 |
| 119 | 999.999999 | 999.9999999 | 999.999999 | 999.999999 | 999.99999999 | 0 |
| 120 | 999.999999 | 999.9999999 | 999.999999 | 999.999999 | 999.99999999 | 0 |

TABLE 11.1 --- continued

| Program Number | C-E (Student) | C-E (Teachers) | C-E (Admin.) | C-E (Parent) | C-E (Cons.) | COST |
|---|---|---|---|---|---|---|
| 121 | 133. | 180. | 146.7 | 190. | 166.7 | 9000 |
| 122 | 7.467 | 2.489 | 3.1111 | 8.867 | 3.1111 | 450000 |
| 123 | .5128 | 1.538 | .769 | 1.282 | 1.79487 | 156000 |
| 124 | 1.2245 | 2.35828 | 1.11111 | 1.746 | 2.56236 | 176400 |
| 125 | 1.24855 | 2.40462 | 1.13295 | 1.78035 | 2.61272 | 173000 |
| 126 | 1.05 | 2.047 | .9765 | 1.54 | 2.1596 | 213000 |
| 127 | 1.41772 | 2.75949 | 1.31646 | 2.07595 | 2.91139 | 158000 |
| 128 | 2.69725 | 8.02752 | 4.04587 | 6.74312 | 9.119 | 218000 |
| 129 | 1.56566 | 3.96465 | 1.94444 | 3.18182 | 4.520 | 158400 |
| 130 | 1.54303 | 3.76855 | 1.83976 | 1.99703 | 4.273 | 134800 |
| 131 | 1.9091 | 25.1948 | 12.2078 | 19.7402 | 28.3117 | 154000 |
| 132 | 4.48087 | 10.2186 | 4.97268 | 8.03279 | 11.257 | 146400 |
| 133 | 2.9304 | 7.03297 | 3.45788 | 5.62637 | 7.73626 | 68250 |
| 134 | 23.075 | 17.041 | 12.499 | 20.058 | 22.3788 | 241300 |
| 135 | 23.075 | 17.041 | 12.499 | 20.058 | 22.3788 | 241300 |
| 136 | 3.43234 | 1.68317 | 1.58416 | 2.64026 | 1.80528 | 606000 |
| 137 | 2.28459 | 1.69565 | 1.29249 | 2.15415 | 2.48221 | 1012000 |
| 138 | 1.59242 | 4.77725 | 2.38863 | 3.98104 | 5.57346 | 422000 |
| 139 | 3.08116 | 6.05227 | 2.86107 | 4.51169 | 6.60248 | 436200 |
| 140 | .423586 | .712395 | .327316 | .500602 | .750903 | 1662000 |
| 141 | .9952 | 1.8756 | .880383 | 1.378 | 2.02871 | 836000 |
| 142 | .658596 | .8523 | .368039 | .523 | .83293 | 826000 |
| 143 | .2409 | .548055 | .264994 | .427604 | .614304 | 3985000 |
| 144 | .131207 | .287927 | .138497 | .222323 | .320729 | 4390000 |
| 145 | .218634 | .5118 | .248447 | .402484 | .576398 | 4025000 |
| 146 | .19076 | .433979 | .209836 | .338599 | .486438 | 3355000 |

<u>Note:</u> C-E is Cost-Effectiveness. All cost-effectiveness data has been divided by a constant, $10^{-8}$. Cost-effectiveness from the different points of view stems from different IMPORT ratings. 999.99 indicates infinite cost-effectiveness (i.e., ≈0 cost).

| Program Number | C-E (Student) | Aggregate Cost | COST |
|---|---|---|---|
| 5 | 999.99999999 | | 0 |
| 6 | 999.99999999 | | 0 |
| 7 | 999.99999999 | | 0 |
| 8 | 999.99999999 | | 0 |
| 9 | 999.99999999 | | 0 |
| 16 | 999.99999999 | | 0 |
| 22 | 999.99999999 | | 0 |
| 110 | 999.99999999 | | 0 |
| 119 | 999.99999999 | | 0 |
| 120 | 999.99999999 | | 0 |
| | | | |
| 64 | 468.533 | $ 0 | 7500 |
| 37 | 261.6 | | 20000 |
| 38 | 234.667 | | 22500 |
| 121 | 133. | | 9000 |
| 2 | 132.313 | | 21162 |
| 41 | 100.8 | | 100000 |
| 94 | 98.9163 | | 98000 |
| 105 | 97.11 | | 19400 |
| 73 | 36.8846 | | 104000 |
| 65 | 36.2 | | 480000 |
| 101 | 33.5922 | | 41200 |
| 55 | 33.12 | | 100000 |
| 11 | 32.9055 | | 153500 |
| 48 | 26.1333 | | 90000 |
| 33 | 24.1633 | | 271900 |
| 134 | 23.075 | | 241300 |
| 135 | 23.075 | | 241300 |
| 90 | 22.3774 | | 212000 |
| 104 | 19.7486 | | 175000 |
| 54 | 19.1822 | | 450000 |
| 40 | 18.9188 | | 960000 |
| 112 | 18.86 | | 344000 |
| 29 | 18.3420 | | 280000 |
| 113 | 16.9778 | | 180000 |
| 21 | 14.5722 | | 37400 |
| 109 | 12.73 | | 115000 |
| 84 | 12.572 | | 250000 |
| 32 | 12.1249 | | 98970 |
| 13 | 11.327 | | 1373000 |
| 50 | 11.0798 | | 432500 |
| 96 | 10.0571 | | 700000 |
| 25 | 9.79044 | | 400800 |
| 86 | 9.15602 | | 975000 |
| 35 | 9.024 | | 500000 |
| | | | |
| 74 | 8.79521 | $ 9,505,432 | 835000 |
| 12 | 8.38131 | | 535000 |
| 56 | 8. | | 146000 |
| 97 | 7.05790 | | 570000 |
| 76 | 7.47 | | 1800000 |
| 122 | 7.467 | | 450000 |
| 72 | 7.2 | | 35000 |
| 115 | 7.2 | | 750000 |
| 93 | 7.13514 | | 444000 |
| 18 | 6.74 | | 250000 |
| 60 | 6.667 | | 1200000 |
| 103 | 6.667 | | 18000 |
| 27 | 6.18865 | | 468600 |
| 99 | 5.52212 | | 452000 |
| 81 | 5.40231 | | 585000 |
| 85 | 5.28696 | | 690000 |

TABLE 11-2

| Program Number | C-E (Student) | Aggregate Cost | COST |
|---|---|---|---|
| 66 | 4.82162 | | 740000 |
| 67 | 4.58667 | | 675000 |
| 30 | 4.5 | | 1230000 |
| 132 | 4.48087 | | 146400 |
| 10 | 4.13 | | 3220000 |
| 2 | 4.1047 | | 3600000 |
| 1 | 4.0125 | | 2233000 |
| 15 | 3.84 | | 1000000 |
| 30 | 3.[illegible]0147 | | 1360000 |
| 42 | 3.[illegible]6264 | | 165000 |
| 116 | 3.[illegible]6 | | 500000 |
| 88 | 3.52 | | 57500 |
| 14 | 3.50588 | | 1530000 |
| 136 | 3.43234 | | 606000 |
| 25 | 3.22917 | | 240000 |
| 57 | 3.2 | | 12500 |
| 26 | 3.19519 | | 2160000 |
| 130 | 3.09116 | | 436200 |
| 79 | 3.0416 | | 5000000 |
| 133 | 3.0304 | | 68250 |
| 117 | 2.944 | | 540000 |
| 75 | 2.8125 | | 2400000 |
| 128 | 2.69725 | | 218000 |
| 45 | 2.65139 | | 2619000 |
| 34 | 2.62182 | $49,499,882 | 1100000 |
| 36 | 2.4 | | 850000 |
| 137 | 2.28459 | | 1012000 |
| 98 | 2.08696 | | 69000 |
| 20 | 2.00618 | | 2265000 |
| 131 | 1.9091 | | 154000 |
| 31 | 1.84615 | | 390000 |
| 78 | 1.6 | | 100000 |
| 138 | 1.59242 | | 422000 |
| 46 | 1.5871 | | 6200000 |
| 129 | 1.56566 | | 158400 |
| 130 | 1.54303 | | 134800 |
| 58 | 1.48109 | | 10900100 |
| 28 | 1.47862 | | 2900000 |
| 127 | 1.41772 | | 158000 |
| 102 | 1.412 | | 2000000 |
| 24 | 1.4104 | | 965000 |
| 82 | 1.4 | | 200000 |
| 125 | 1.24855 | | 173000 |
| 124 | 1.2245 | | 176400 |
| 42 | 1.16519 | | 6550000 |
| 59 | 1.128 | | 750000 |
| 126 | 1.05 | | 213000 |
| 80 | 1.02568 | | 9500000 |
| 141 | .9952 | | 836000 |
| 114 | .97111 | | 900000 |
| 4 | .9494 | $98,476,582 | 4150000 |
| 107 | .929 | | 620000 |
| 77 | .854 | | 1000000 |
| 62 | .812549 | | 9562500 |
| 92 | .8095 | | 420000 |
| 70 | .742857 | | 1400000 |
| 52 | .722 | | 2250000 |
| 47 | .672 | | 826000 |
| 142 | .658596 | | 1500000 |
| 44 | .592 | | |

TABLE 11.2

| Program Number | C-E (Student) | COST |
|---|---|---|
| 123 | .5128 | 156000 |
| 111 | .497778 | 900000 |
| 140 | .423586 | 1662000 |
| 100 | .4183 | 76500 |
| 68 | .410256 | 390000 |
| 61 | .39 | 6000000 |
| 108 | .3808 | 625000 |
| 69 | .379447 | 759000 |
| 106 | .288 | 1436000 |
| 143 | .2409 | 3985000 |
| 145 | .218634 | 4025000 |
| 87 | .196 | 6020000 |
| 146 | .19076 | 3355000 |
| 71 | .157193 | 1425000 |
| 53 | .15234 | 15100000 |
| 82 | .139522 | 41800000 |
| 144 | .131207 | 4390000 |
| 63 | .10667 | 5250000 |
| 51 | .106333 | 24000000 |
| 89 | .08569 | 35500000 |
| 91 | .0784 | 306000 |
| 17 | .0548743 | 35000000 |
| 10 | .0 | 880000 |
| 23 | .0 | |
| 49 | .0 | 2375000 |
| 118 | .0 | 300000 |

TABLE 11.2-- conclusion

| Program Number | C-E (Teacher) | Aggregate Cost | COST |
|---|---|---|---|
| 5 | 00.0000000 | | 0 |
| 6 | 00.000000 | | 0 |
| 7 | 00.0000000 | | 0 |
| 8 | 00.0000000 | | 0 |
| 9 | 00.000000 | | 0 |
| 16 | 00.000000 | | 0 |
| 22 | 00.000000 | | 0 |
| 110 | 00.0000000 | | 0 |
| 119 | 00.000000 | | 0 |
| 120 | 00.000000 | | 0 |
| 64 | 91.0933 | $ 0 | 7500 |
| 38 | 45.9378 | | 22500 |
| 37 | 45.64 | | 20000 |
| 2 | 21.4346 | | 21162 |
| 101 | 19.767 | | 41200 |
| 121 | 18.0 | | 9000 |
| 105 | 16.2485 | | 19400 |
| 41 | 9.352 | | 100000 |
| 57 | 6.784 | | 12500 |
| 48 | 6.64 | | 90000 |
| 11 | 5.79544 | | 153500 |
| 54 | 4.90311 | | 450000 |
| 55 | 4.624 | | 100000 |
| 21 | 3.4893 | | 37400 |
| 94 | 3.4408 | | 98000 |
| 98 | 3.2 | | 69000 |
| 50 | 3.09642 | | 432500 |
| 29 | 2.77929 | | 280000 |
| 73 | 2.74615 | | 104000 |
| 131 | 2.51948 | | 154000 |
| 23 | 2.22717 | | 271900 |
| 65 | 2.21 | | 480000 |
| 113 | 2.11333 | | 180000 |
| 40 | 2.10656 | | 960000 |
| 32 | 1.72982 | | 98970 |
| 134 | 1.7041 | | 241300 |
| 135 | 1.7041 | | 241300 |
| 96 | 1.49243 | | 700000 |
| 112 | 1.414 | | 344000 |
| 84 | 1.3104 | | 250000 |
| 31 | 1.28 | | 390000 |
| 81 | 1.19173 | | 585000 |
| 109 | 1.08 | | 115000 |
| 56 | 1.04658 | | 146000 |
| 132 | 1.02186 | | 146400 |
| 90 | .94717 | | 212000 |
| 78 | .912 | | 100000 |
| 12 | .877757 | | 535000 |
| 128 | .802752 | | 218000 |
| 67 | .778667 | | 675000 |
| 104 | .754286 | | 175000 |
| 43 | .707979 | | 165000 |
| 88 | .706783 | | 57500 |
| 133 | .703297 | | 68250 |
| 118 | .672 | | 300000 |
| 95 | .645833 | $9,872,282 | 240000 |
| 60 | .61 | | 1200000 |
| 139 | .605227 | | 436200 |
| 35 | .5892 | | 500000 |
| 15 | .568 | | 1000000 |



TABLE 11.3

| Program Number | C-E (Teacher) | Aggregate Cost | COST |
|---|---|---|---|
| 116 | 5.568 | | 500000 |
| 30 | 5.53252 | | 1230000 |
| 102 | 5.504 | | 2000000 |
| 3 | 5.2169 | | 3600000 |
| 36 | 5.15294 | | 850000 |
| 97 | 5.01754 | | 570000 |
| 13 | 4.88274 | | 1373000 |
| 138 | 4.77725 | | 422000 |
| 115 | 4.56 | | 750000 |
| 20 | 4.51744 | | 2265000 |
| 117 | 4.267 | | 540000 |
| 59 | 4.256 | | 750000 |
| 74 | 4.22515 | | 935000 |
| 79 | 4.1616 | | 5000000 |
| 45 | 4.1176 | | 2619000 |
| [illegible] | 3.96465 | | 158400 |
| 1 | 3.8603 | | 2233000 |
| 18 | 3.84 | | 250000 |
| 130 | 3.76855 | | 134800 |
| 25 | 3.69261 | | 400800 |
| 66 | 3.67568 | | 740000 |
| 72 | 3.6 | | 35000 |
| 83 | 3.5 | | 200000 |
| 86. | 3.49538 | | 975000 |
| 19 | 3.4636 | | 3229000 |
| 70 | 3.44 | | 1400000 |
| 28 | 3.34345 | | 2900000 |
| 103 | 3.333 | | 18000 |
| 75 | 2.86875 | $49,231,482 | 2400000 |
| 93 | 2.77477 | | 444000 |
| 127 | 2.75949 | | 158000 |
| 47 | 2.624 | | 2250000 |
| 34 | 2.53818 | | 1100000 |
| 122 | 2.483 | | 450000 |
| 108 | 2.464 | | 625000 |
| 76 | 2.445 | | 1800000 |
| 125 | 2.40462 | | 173000 |
| 124 | 2.35828 | | 176400 |
| 114 | 2.17778 | | 900000 |
| 39 | 2.11324 | | 1360000 |
| 126 | 2.047 | | 213000 |
| 141 | 1.8756 | | 836000 |
| 14 | 1.85882 | | 1530000 |
| 85 | 1.78551 | | 690000 |
| 137 | 1.69565 | | 1012000 |
| 136 | 1.68317 | | 606000 |
| 24 | 1.66936 | | 865000 |
| 27 | 1.54716 | | 468600 |
| 123 | 1.538 | | 156000 |
| 46 | 1.5329 | | 6200000 |
| 92 | 1.50476 | | 420000 |
| 58 | 1.32035 | | 10900100 |
| 77 | 1.295 | | 1000000 |
| 63 | 1.29219 | | 5250000 |
| 61 | 1.26 | | 6000000 |
| 42 | .984427 | $97,214,582 | 6550000 |
| 44 | .928 | | 1500000 |
| 142 | .8523 | | 826000 |
| 4 | .83976 | | 4150000 |
| 49 | .754526 | | 2375000 |

TABLE 11.3 -- continued

| Program Number | C-E (Teacher) | Aggregate Cost | COST |
|---|---|---|---|
| 26 | .748148 | | 2160000 |
| 140 | .712395 | | 1662000 |
| 10 | .65909 | | 880000 |
| 17 | .650057 | | 35000000 |
| 99 | .637168 | | 452000 |
| 52 | .593 | | 10000000 |
| 143 | .548055 | | 3985000 |
| 145 | .5118 | | 4025000 |
| 80 | .475 | | 9500000 |
| 146 | .433979 | | 3355000 |
| 100 | .4183 | | 76500 |
| 62 | .356418 | | 9562500 |
| 107 | .3097 | | 620000 |
| 144 | .287927 | | 4390000 |
| 111 | .248889 | | 900000 |
| 106 | .213 | | 1436000 |
| 68 | .205128 | | 390000 |
| 69 | .189723 | | 750000 |
| 53 | .135319 | | 15100000 |
| 51 | .091 | | 24000000 |
| 71 | .0786 | | 1425000 |
| 87 | .066445 | | 6020000 |
| 39 | .0659 | | 35500000 |
| 91 | .0392 | | 306000 |
| 82 | .038756 | | 41800000 |
| 23 | | | |

| Program Number | C-E (Administrator) | Aggregate Cost | COST |
|---|---|---|---|
| 5 | 999999.9999 | | 0 |
| 6 | 999999.9999 | | 0 |
| 7 | 999999.9999 | | 0 |
| 8 | 999999.9999 | | 0 |
| 9 | 999999.9999 | | 0 |
| 16 | 999999.9999 | | 0 |
| 22 | 999999.9999 | | 0 |
| 110 | 999999.9999 | | 0 |
| 119 | 999999.9999 | | 0 |
| 120 | 999999.9999 | | 0 |
| | | $ 0 | |
| 64 | 468.533 | | 7500 |
| 38 | 327.822 | | 22500 |
| 37 | 258. | | 20000 |
| 2 | 166.903 | | 21162 |
| 121 | 146.7 | | 9000 |
| 105 | 123.4 | | 19400 |
| 78 | 108. | | 100000 |
| 101 | 97.67 | | 41200 |
| 41 | 86. | | 100000 |
| 55 | 52.72 | | 100000 |
| 48 | 44.4444 | | 90000 |
| 31 | 38.1538 | | 390000 |
| 11 | 32.99 | | 153500 |
| 57 | 29.44 | | 12500 |
| 73 | 26.1827 | | 104000 |
| 54 | 25.9733 | | 450000 |
| 94 | 25.0408 | | 98000 |
| 56 | 20.7671 | | 146000 |
| 29 | 19.8429 | | 280000 |
| 65 | 18.2667 | | 480000 |
| 21 | 16.9786 | | 37400 |

TABLE 11.4

| Program Number | C-E (Administrator) | Aggregate Cost | COST |
|---|---|---|---|
| 33 | 1.54689 | | 271900 |
| 50 | 1.48717 | | 432500 |
| 67 | 1.41422 | | 675000 |
| 98 | 1.32174 | | 69000 |
| 40 | 1.30594 | | 960000 |
| 134 | 1.2499 | | 241300 |
| 135 | 1.2499 | | 241300 |
| 131 | 1.22078 | | 154000 |
| 96 | 1.17943 | | 700000 |
| 112 | 1.17 | | 344000 |
| 113 | 1.01778 | | 180000 |
| 90 | .963264 | | 212000 |
| 32 | .921491 | | 98970 |
| 109 | .850435 | | 115000 |
| 60 | .821667 | | 1200000 |
| 84 | .7532 | | 250000 |
| 72 | .72 | | 35000 |
| 12 | .679626 | | 535000 |
| 81 | .678462 | | 585000 |
| 103 | .6667 | $9,982,132 | 18000 |
| 10 | .55625 | | 880000 |
| 115 | .5088 | | 750000 |
| 132 | .497268 | | 146400 |
| 74 | .474251 | | 835000 |
| 35 | .474 | | 500000 |
| 13 | .47196 | | 1373000 |
| 15 | .448 | | 1000000 |
| 104 | .438857 | | 175000 |
| 25 | .429142 | | 400800 |
| 88 | .428522 | | 57[illegible]00 |
| 97 | .424561 | | 570000 |



TABLE 11.4--continued

| Program Number | C-E (Administrator) | Aggregate Cost | COST |
|---|---|---|---|
| 116 | 4.184 | | 500000 |
| 128 | 4.04587 | | 218000 |
| 18 | 3.84 | | 250000 |
| 70 | 3.65143 | | 1400000 |
| 95 | 3.64583 | | 240000 |
| 79 | 3.5004 | | 5000000 |
| 133 | 3.45788 | | 68250 |
| 30 | 3.34959 | | 1230000 |
| 35 | 3.21882 | | 850000 |
| 3 | 3.2122 | | 3600000 |
| 43 | 3.2 | | 165000 |
| 45 | 3.11875 | | 2619000 |
| 122 | 3.1111 | | 450000 |
| 117 | 3.0815 | | 540000 |
| 76 | 3.075 | | 1800000 |
| 59 | 2.952 | | 750000 |
| 1 | 2.9028 | | 2233000 |
| 139 | 2.86107 | | 436200 |
| 19 | 2.807 | | 3229000 |
| 20 | 2.61015 | | 2265000 |
| 66 | 2.55135 | | 740000 |
| 118 | 2.52 | | 300000 |
| 75 | 2.48625 | | 2400000 |
| 138 | 2.38863 | | 422000 |
| 102 | 2.344 | $48,393,282 | 2000000 |
| 39 | 2.14853 | | 1360000 |
| 83 | 2.1 | | 200000 |
| 34 | 2.05455 | | 1100000 |
| 28 | 2.03862 | | 2900000 |
| 86 | 2.01846 | | 975000 |
| 100 | 1.98693 | | 76500 |



TABLE 11-4 — continued

| Program Number | C-E (Administrator) | Aggregate Cost | COST |
|---|---|---|---|
| 77 | 1.981 | | 1000000 |
| 93 | 1.95495 | | 444000 |
| 129 | 1.94444 | | 158400 |
| 130 | 1.83076 | | 134800 |
| 27 | 1.81301 | | 468600 |
| 136 | 1.58416 | | 606000 |
| 127 | 1.31646 | | 158000 |
| 108 | 1.31 | | 625000 |
| 114 | 1.30667 | | 900000 |
| 137 | 1.29249 | | 1012000 |
| 47 | 1.28 | | 2250000 |
| 14 | 1.25882 | | 1530000 |
| 85 | 1.2058 | | 690000 |
| 58 | 1.16182 | | 10900100 |
| 46 | 1.13806 | | 6200000 |
| 125 | 1.13295 | | 173000 |
| 124 | 1.11111 | | 176400 |
| 24 | 1.00809 | | 865000 |
| 26 | .985185 | | 2160000 |
| 92 | .981 | | 420000 |
| 126 | .9765 | | 213000 |
| 42 | .880611 | | 6550000 |
| 141 | .880383 | | 836000 |
| 123 | .769 | | 156000 |
| 61 | .68 | $95,631,082 | 6000000 |
| 4 | .64096 | | 4150000 |
| 63 | .560762 | | 5250000 |
| 111 | .497778 | | 900000 |
| 17 | .465943 | | 35000000 |
| 52 | .4315 | | 10000000 |
| 44 | .413333 | | 1500000 |

TABLE 11.4 -- continued

| Program Number | C-E (Administrator) | Aggregate Cost | COST |
|---|---|---|---|
| 68 | .410256 | | 390000 |
| 107 | .387 | | 620000 |
| 69 | .379447 | | 759000 |
| 99 | .37699 | | 452000 |
| 142 | .368039 | | 826000 |
| 140 | .327316 | | 1662000 |
| 49 | .282947 | | 2375000 |
| 143 | .264994 | | 3985000 |
| 80 | .260842 | | 9500000 |
| 145 | .248447 | | 4025000 |
| 62 | .242614 | | 9562500 |
| 146 | .209836 | | 3355000 |
| 71 | .157193 | | 1425000 |
| 144 | .138497 | | 4390000 |
| 106 | .1128 | | 1436000 |
| 53 | .105957 | | 15100000 |
| 91 | .0784 | | 306000 |
| 82 | .077512 | | 41800000 |
| 87 | .076412 | | 6020000 |
| 51 | .04067 | | 24000000 |
| 89 | .03397 | | 35500000 |
| 23 | | | |

TABLE 11 4 -- conclusion

| Program Number | C-E (Parent) | Aggregate Cost | COST |
|---|---|---|---|
| 5 | 999.999999999 | | 0 |
| 6 | 999.999999999 | | 0 |
| 7 | 999.999999999 | | 0 |
| 8 | 999.999999999 | | 0 |
| 9 | 999.99999999 | | 0 |
| 16 | 999.99999999 | | 0 |
| 22 | 999.99999999 | | 0 |
| 110 | 999.99999999 | | 0 |
| 119 | 999.99999999 | | 0 |
| 120 | 999.99999999 | | 0 |
| 37 | 327. | $ 0 | 20000 |
| 39 | 227.778 | | 22500 |
| 2 | 165.769 | | 21162 |
| 41 | 118.88 | | 100000 |
| 105 | 117.526 | | 19400 |
| 121 | 100. | | 9000 |
| 55 | 48.64 | | 100000 |
| 11 | 46.9577 | | 153500 |
| 73 | 44.4231 | | 104000 |
| 94 | 33.3030 | | 98000 |
| 57 | 32. | | 12500 |
| 101 | 29.126 | | 41200 |
| 54 | 27.1822 | | 450000 |
| 64 | 26.133 | | 7500 |
| 65 | 24.4333 | | 480000 |
| 29 | 24.0214 | | 280000 |
| 90 | 23.9622 | | 212000 |
| 134 | 20.059 | | 241300 |
| 135 | 20.058 | | 241300 |
| 131 | 19.7403 | | 154000 |
| 33 | 18.5767 | | 271900 |
| 72 | 18. | | 35000 |
| 48 | 17.3333 | | 90000 |
| 103 | 16.667 | | 18000 |
| 112 | 16.66 | | 344000 |
| 32 | 15.3582 | | 98970 |
| 98 | 13.913 | | 69000 |
| 96 | 12.8071 | | 700000 |
| 56 | 12.8767 | | 146000 |
| 40 | 11.6063 | | 960000 |
| 74 | 11.4683 | | 835000 |
| 13 | 10.6305 | | 1373000 |
| 100 | 10.0957 | | 115000 |
| 115 | 9.264 | | 750000 |
| 122 | 8.867 | | 450000 |
| 76 | 8.835 | $9,023,232 | 1800000 |
| 12 | 8.79252 | | 535000 |
| 113 | 8.2 | | 180000 |
| 50 | 8.08324 | | 432500 |
| 60 | 8.05 | | 1200000 |
| 132 | 8.03279 | | 146400 |
| 18 | 6.98 | | 250000 |
| 129 | 6.74312 | | 218000 |
| 67 | 6.73778 | | 675000 |
| 95 | 6.5625 | | 240000 |
| 25 | 6.48703 | | 400800 |
| 31 | 6.15385 | | 390000 |
| 97 | 5.97805 | | 570000 |
| 117 | 5.69889 | | 540000 |
| 133 | 5.62637 | | 68250 |

TABLE 11.5

| Program Number | C-E (Parent) | Aggregate Cost | COST |
|---|---|---|---|
| 91 | 5.52821 | | 585000 |
| 35 | 5.436 | | 500000 |
| 15 | 5.32 | | 1000000 |
| 84 | 5.22 | | 250000 |
| 116 | 5.2 | | 500000 |
| 104 | 5.07429 | | 175000 |
| 93 | 5.00001 | | 444000 |
| 3 | 4.5831 | | 3600000 |
| 139 | 4.51169 | | 436200 |
| [illegible]9 | 4.38261 | | 57500 |
| 45 | 4.23673 | | 2610000 |
| 118 | 4.2 | | 300000 |
| 10 | 4.1598 | | 3229000 |
| 78 | 4. | | 100000 |
| 138 | 3.98104 | | 422000 |
| 132 | 3.876 | | 2000000 |
| 75 | 3.8475 | | 2400000 |
| 83 | 3.5 | | 200000 |
| 30 | 3.49593 | | 1230000 |
| 79 | 3.4032 | | 5000000 |
| 59 | 3.32 | | 750000 |
| 1 | 3.1863 | | 2233000 |
| 129 | 3.18192 | | 158400 |
| 36 | 3.12706 | | 850000 |
| 86 | 3.10154 | | 975000 |
| 95 | 3.03768 | | 690000 |
| 27 | 2.77422 | | 468600 |
| 136 | 2.64026 | | 606000 |
| 43 | 2.61819 | | 165000 |
| 39 | 2.58529 | | 1360000 |
| 14 | 2.39412 | $49,972,882 | 1530000 |
| 20 | 2.34879 | | 2265000 |
| 114 | 2.17778 | | 900000 |
| 137 | 2.15415 | | 1012000 |
| 77 | 2.135 | | 1000000 |
| 34 | 2.13091 | | 1100000 |
| 66 | 2.10811 | | 740000 |
| 127 | 2.07595 | | 158000 |
| 130 | 1.99703 | | 134800 |
| 58 | 1.85000 | | 10900100 |
| 47 | 1.79733 | | 2250000 |
| 125 | 1.78035 | | 173000 |
| 124 | 1.746 | | 176400 |
| 21 | 1.73797 | | 37400 |
| 26 | 1.5556 | | 2160000 |
| 126 | 1.54 | | 213000 |
| 141 | 1.378 | | 836000 |
| 24 | 1.35954 | | 865000 |
| 92 | 1.3238 | | 420000 |
| 123 | 1.282 | | 156000 |
| 111 | 1.2444 | | 900000 |
| 46 | 1.2 | | 6200000 |
| 42 | 1.12977 | | 6550000 |
| 28 | 1.10621 | | 2900000 |
| 107 | 1.1032 | | 620000 |
| 100 | 1.04575 | | 76500 |
| 68 | 1.02564 | | 390000 |
| 69 | .948617 | | 759000 |
| 63 | .579048 | $95,395,082 | 5250000 |
| 4 | .54217 | | 4150000 |

TABLE 11.5 -- continued

| Program Number | C-E (Parent) | Aggregate Cost | COST |
|---|---|---|---|
| 142 | .523 | | 826000 |
| 70 | .514286 | | 1400000 |
| 140 | .500602 | | 1662000 |
| 49 | .471579 | | 2375000 |
| 143 | .427604 | | 3985000 |
| 61 | .41 | | 6000000 |
| 17 | .408857 | | 35000000 |
| 145 | .402484 | | 4025000 |
| 71 | .392982 | | 1425000 |
| 80 | .343368 | | 9500000 |
| 146 | .338599 | | 3355000 |
| 52 | .3 | | 10000000 |
| 62 | .291765 | | 9562500 |
| 44 | .290667 | | 1500000 |
| 108 | .224 | | 625000 |
| 144 | .222323 | | 4390000 |
| 91 | .196 | | 306000 |
| 106 | .175484 | | 1436000 |
| 82 | .147273 | | 41800000 |
| 87 | .130535 | | 6020000 |
| 53 | .118298 | | 15100000 |
| 99 | .0849558 | | 452000 |
| 89 | .08366 | | 35500000 |
| 51 | .0733 | | 24000000 |
| 10 | | | 880000 |
| 23 | | | |

TABLE 11.5 -- conclusion

| Program Number | C-E (Consultant) | Aggregate Cost | COST |
|---|---|---|---|
| 5 | 9999.9999999999 | | 0 |
| 6 | 9999.9999999999 | | 0 |
| 7 | 9999.9999999999 | | 0 |
| 8 | 9999.9999999999 | | 0 |
| 9 | 9999.9999999999 | | 0 |
| 16 | 9999.9999999999 | | 0 |
| 22 | 9999.9999999999 | | 0 |
| 110 | 9999.9999999999 | | 0 |
| 119 | 9999.9999999999 | | 0 |
| 120 | 9999.9999999999 | | 0 |
| 64 | 728. | $0 | 7500 |
| 38 | 370.222 | | 22500 |
| 37 | 376.2 | | 20000 |
| 2 | 200.359 | | 21162 |
| 121 | 166.7 | | 9000 |
| 101 | 159.223 | | 41200 |
| 105 | 154. | | 19400 |
| 41 | 88.48 | | 100000 |
| 57 | 85.76 | | 12500 |
| 55 | 58.72 | | 100000 |
| 48 | 54.9333 | | 90000 |
| 94 | 37.7143 | | 98000 |
| 54 | 36.2133 | | 450000 |
| 73 | 34.7208 | | 104000 |
| 11 | 32.7818 | | 153500 |
| 78 | 29.76 | | 100000 |
| 131 | 28.3117 | | 154000 |
| 98 | 26.4348 | | 69000 |
| 29 | 25.8429 | | 280000 |
| 32 | 25.1389 | | 98970 |
| 33 | 23.6558 | | 271900 |
| 134 | 22.3788 | | 241300 |
| 135 | 22.3788 | | 241300 |
| 21 | 22.0588 | | 37400 |
| 65 | 18.5667 | | 480000 |
| 40 | 18.5438 | | 960000 |
| 31 | 17.8051 | | 390000 |
| 50 | 16.6659 | | 432500 |
| 72 | 14.4 | | 35000 |
| 90 | 14.3962 | | 212000 |
| 96 | 13.7143 | | 700000 |
| 84 | 13.664 | | 250000 |
| 103 | 13.33 | | 18000 |
| 113 | 12.533 | | 180000 |
| 112 | 12.51 | | 344000 |
| 100 | 11.8435 | | 115000 |
| 132 | 11.257 | | 146400 |
| 81 | 10.159 | | 585000 |
| 128 | 9.119 | | 219000 |
| 56 | 8.38356 | | 146000 |
| 25 | 7.98403 | | 400800 |
| 12 | 7.83551 | | 535000 |
| 133 | 7.73626 | | 68250 |
| 104 | 7.13143 | | 175000 |
| 62 | 7.08333 | $9,133,582 | 200000 |
| 139 | 6.60248 | | 436200 |
| 13 | 6.32192 | | 1373000 |
| 35 | 6.264 | | 500000 |
| 115 | 6.192 | | 750000 |
| 42 | 6.10909 | | 165000 |

| Program Number | C-E (Consultants) | Agg. Cost | COST |
|---|---|---|---|
| 97 | 6.03500 | | 570000 |
| 118 | 5.88 | | 300000 |
| 95 | 5.72917 | | 240000 |
| 138 | 5.57346 | | 422000 |
| 116 | 5.296 | | 500000 |
| 15 | 5.2 | | 1000000 |
| 3 | 5.11 | | 3600000 |
| 30 | 4.94050 | | 1230000 |
| 74 | 4.74251 | | 835000 |
| 36 | 4.68706 | | 950000 |
| 18 | 4.68 | | 250000 |
| 88 | 4.66097 | | 57500 |
| 93 | 4.64865 | | 444000 |
| 129 | 4.520 | | 158400 |
| 19 | 4.32828 | | 3220000 |
| 130 | 4.273 | | 134800 |
| 117 | 4.0296 | | 540000 |
| 50 | 4.024 | | 750000 |
| 20 | 3.96291 | | 2265000 |
| 66 | 3.94595 | | 740000 |
| 86 | 3.79077 | | 975000 |
| 1 | 3.6421 | | 2233000 |
| 102 | 3.46 | | 2000000 |
| 45 | 3.43643 | | 2610000 |
| 79 | 3.3664 | | 5000000 |
| 70 | 3.21143 | | 1400000 |
| 122 | 3.1111 | | 450000 |
| 76 | 3.075 | | 1800000 |
| 28 | 2.98759 | $48,150,482 | 2900000 |
| 127 | 2.91139 | | 158000 |
| 85 | 2.89855 | | 690000 |
| 34 | 2.88727 | | 1100000 |
| 75 | 2.75625 | | 2400000 |
| 27 | 2.72087 | | 468600 |
| 125 | 2.61272 | | 173000 |
| 124 | 2.56236 | | 176400 |
| 137 | 2.48221 | | 1012000 |
| 39 | 2.28071 | | 1360000 |
| 47 | 2.18133 | | 2250000 |
| 77 | 2.163 | | 1000000 |
| 126 | 2.1596 | | 213000 |
| 14 | 2.03529 | | 1530000 |
| 141 | 2.02871 | | 836000 |
| 108 | 1.9936 | | 625000 |
| 24 | 1.80909 | | 865000 |
| 136 | 1.80528 | | 606000 |
| 123 | 1.79487 | | 156000 |
| 58 | 1.60430 | | 10900100 |
| 17 | 1.56818 | | 880000 |
| 26 | 1.47407 | | 2160000 |
| 42 | 1.4229 | | 6550000 |
| 83 | 1.4 | | 200000 |
| 92 | 1.28571 | | 420000 |
| 46 | 1.28 | | 6200000 |
| 100 | 1.2549 | | 76500 |
| 63 | 1.11543 | | 5250000 |
| 67 | 1.09867 | | 675000 |
| 111 | .99556 | $99,981,082 | 900000 |
| 114 | .87111 | | 900000 |
| 142 | .83293 | | 826000 |

TABLE 11.6 -- continued

| Program Number | C-E (Consultant) | Aggregate Cost | COST |
|---|---|---|---|
| 4 | 9280 | 4150000 | |
| 48 | .820512 | 320000 | |
| 61 | .778 | 6000000 | |
| 44 | .770667 | 1500000 | |
| 60 | .752833 | 750000 | |
| 140 | .750003 | 1662000 | |
| 49 | .660211 | 2375000 | |
| 142 | .614304 | 3085000 | |
| 52 | .586 | 10000000 | |
| 145 | .576200 | 4025000 | |
| 143 | .486422 | 2255000 | |
| 117 | .466457 | 35000000 | |
| 80 | .412632 | 9500000 | |
| 1 7 | .2871 | 620000 | |
| 90 | .361062 | 452000 | |
| 62 | .347712 | 9562500 | |
| 144 | .326720 | 4390000 | |
| 71 | .214286 | 1425000 | |
| 106 | .175427 | 1436000 | |
| 91 | .156 | 306000 | |
| 53 | .150630 | 15100000 | |
| 97 | .126246 | 6020000 | |
| 82 | .116269 | 41800000 | |
| 51 | .08717 | 24000000 | |
| 93 | .08265 | 35500000 | |

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TABLE 11 6 -- conclusion

## Appendix

### Data Sources for Long-Range Planning Models

Though each of the BIA long-range planning models requires a unique matrix of input data, the sources of information for all of the models have basic commonalities. It therefore makes sense to gather data for the models by source, rather than by model. Listed below are the eight primary data sources and their special problems. Following the list of sources, a table of all model input variables is provided with probable source of information noted. In cases where data is available from several sources, each is noted.

The eight data sources are:

1. Special Census of Indian Areas: This census must be made to provide necessary information about the Indian population to be served by BIA schools. It can be made under contract by the Bureau of the Census, or possibly, by requesting the Census Bureau to include special information in their regular census. Though the former option would be costly, it will probably be necessary at least until the 1980 Census. The information need only be gathered once every five years.

2. School Survey: A once-per-year survey of all BIA schools should be made to gather data not presently obtained by the IADC. This survey will be necessary until the IADC can incorporate the new informational needs into its ongoing system.

3. Indian Affairs Data Center: The IADC presently gathers a great deal of data which can be used by the models. Use of the source will involve the tasks of 1) monitoring IADC collection processes to see that they are as accurate as possible, and 2) directing the flow of presently collected data to the long-range planning models.

4. Policy Data Committee: This committee has the responsibility for developing policy standards, as is discussed in Volume I of this report.

5. <u>Systems Analysis Office</u>: Certain of the information required by the models requires specification by the office designing the planning system. Other information in this category can be gathered by library research or special inquiry.

6. <u>User Specification</u>: Information of this type must be obtained from the user when he requests a computer run. It should therefore be included on a "request for run" form to be filled out by the user.

7. <u>Output from Other Models:</u> This information need not be gathered. However, input and output formats between models must be coordinated, and a model which provides the information must be run before the model needing the information can be run.

8. <u>Other</u>: Two special cases of data needs were found. First, the Finance Management Information System requires budget data which is already recorded, and second, the School Investment Model requires a system-wide achievement test program.

## MODEL INPUT VARIABLES AND PROBABLE SOURCES

| Model: | Variable: | 1. Census | 2. School Survey | 3. IADC | 4. Policy Data Committee | 5. Systems Analysis Office | 6. User Specification | 7. Output from Previous Model | 8. Other |
|---|---|---|---|---|---|---|---|---|---|
| POPULATION PROJECTION MODEL | $P_{jo}$ | * | | | | | | | |
| | $r_{dj}$ | * | | | | | | | |
| | $R_{bo}$ | * | | | | | | | |
| | $R_{mo}$ | * | | | | | | | |
| | $T$ | | | | | | * | | |
| | $Y_o$ | | | | | | * | | |
| | $\varsigma$ | * | | | | | | | |
| | $P^{(2)}_{bjo}$ | * | | | | | | | |
| | $P_{mj}$ | * | | | | | | | |
| | $\sigma$ | * | | | | | | | |
| ENROLLMENT PROJECTION MODEL | $D_{ik}$ | | | | | | * | | |
| | $n_{ik}$ | | * | | | | | | |
| | $P_{jt}$ | | | | | | | * | |
| | $T$ | | | | | | * | | |

## MODEL INPUT VARIABLES AND PROBABLE SOURCES

Sources: 1. Census; 2. School Survey; 3. IADC; 4. Policy Data Committee; 5. Systems Analysis Office; 6. User Specification; 7. Output from Previous Model; 8. Other

| Model: | Variable: | 1. Census | 2. School Survey | 3. IADC | 4. Policy Data Committee | 5. Systems Analysis Office | 6. User Specification | 7. Output from Previous Model | 8. Other |
|---|---|---|---|---|---|---|---|---|---|
| FACILITIES PLANNING MODEL | $F_{i,j,K,M,L}$ | | * | * | | | | | |
| | $ENROL_{i,j,K,M}$ | | * | | | | | | |
| | $DF_{i,j,K,M,L}$ | | | | | | * | | |
| | Y | | | | | | * | | |
| | $ENAP_{i,j,M}$ | | | | | | | * | |
| | YMAX | | | | | | * | | |
| | jMAX(i) | | | | | | * | | |
| | IMAX | | | | | | * | | |
| ECONOMIC PROJECTION MODEL | $VALUE_{i,J}$ | | | | | * | | | |
| | $COST_{I,J}$ | | | | | * | | | |
| | $TRATE_{I,J}$ | | | | | * | | | |
| | $FAROUT_{I,J,K,L}$ | | | | | * | | | |
| | $SUPLAB_{K,L}$ | | | * | | | | | |
| | $TRASE_1$ | | | | | * | | | |
| | $TINDEX_1$ | | | | | * | | | |
| | $LINDEX_1$ | | | | | * | | | |

<u>MODEL INPUT VARIABLES</u>

<u>AND PROBABLE SOURCES</u>

| Model: | Variable: | 1. Census | 2. School Survey | 3. IADC | 4. Policy Data Committee | 5. Systems Analysis Office | 6. User Specification | 7. Output from Previous Model | 8. Other |
|---|---|---|---|---|---|---|---|---|---|
| FACILITIES LOCATION MODEL | $SCHOOL_{i,j}$ | | | | | | | | |
| | $j = 1$ | | * | | | | | | |
| | $j = 2$ | | * | | | | | | |
| | $j = 3$ | | * | | | | | | |
| | $j = 4$ | | | | | * | | | |
| | $j = 5$ | | | | | * | | | |
| | $j = 6, \ldots, 17$ | | | | | | * | | |
| | $ECON_{K,L}$ | | | | | | | * | |
| | $SNOW_{K,L}$ | | * | | | | | | |
| | $POPUP_{M}$ | | | | | | | * | |
| | WEIGHT | | | | | | * | | |
| | $SCHNEW_{NEW,i,j}$ | | | | | | * | | |
| | $GRADE_{M}$ | | * | | | | | | |
| | BOARD1 | | * | | | | | | |
| | BOARD2 | | | | | | * | | |
| | PRESENT | | | | | | * | | |
| | FUTURE | | | | | | * | | |

## MODEL INPUT VARIABLES AND PROBABLE SOURCES

| Model: | Variable: | 1. Census | 2. School Survey | 3. IADC | 4. Policy Data Committee | 5. Systems Analysis Office | 6. User Specification | 7. Output from Previous Model | 8. Other |
|---|---|---|---|---|---|---|---|---|---|
| PERSONNEL PLANNING MODEL | | | | | | | | | |
| | $PERSON_2$ | | | * | | | | | |
| | $PERSON_3$ | | | * | | | | | |
| | $PERSON_4$ | | | * | | | | | |
| | $EXRATE_{K,L}$ | | * | | | | | | |
| | EXAGE | | | | * | | | | |
| | $INRATE_{K,L}$ | | * | | | | | | |
| | $PERBUD_J$ | | | | | | * | | |
| | Function(J, NSC, $\overrightarrow{NSC}$) | | | | * | | | | |
| | $PERREQ_J$ | | | | * | | | | |
| | $\overrightarrow{NSC}$ and $\overrightarrow{NAG}$ | | | | | | | * | |
| | $DLTAPR_J$ | | | | | | * | | |
| | $COST_J$ | | | | * | | | | |
| | BLOWUP | | | | * | | | | |
| | $ICOD_J$ | | | | | * | | | |

## MODEL INPUT VARIABLES AND PROBABLE SOURCES

| Model: | Variable: | 1. Census | 2. School Survey | 3. IADC | 4. Policy Data Committee | 5. Systems Analysis Office | 6. User Specification | 7. Output from Previous Model | 8. Other |
|---|---|---|---|---|---|---|---|---|---|
| EQUIPMENT PROJECTION MODEL | | | | | | | | | |
| | $ITEMAGE_{I,J}$ | | | * | | | | | |
| | $MAINTCOST_{I,J}$ | | * | | * | | | | |
| | Function FACIL(I, J, NSC, $\overrightarrow{NSC}$) | | | | * | | | | |
| | $\overrightarrow{NSC}$ | | | | | | | * | |
| | $\overrightarrow{NAG}$ | | | | | | | * | |
| | $DEF_{I,J}$ | | | | * | | | | |
| | $EQUIPLIFE_{I,J}$ | | * | | * | | | | |
| | $DESBYYR_{I,J}$ | | | | * | | * | | |
| | $PRICE_{I,J}$ | | | | | * | | | |
| | BLOWUP | | | | * | | | | |
| | ICOD | | | | | * | | | |
| FINANCE MANAGEMENT INFORMATION SYSTEM MODEL | | | | | | | | | |
| | Budget Information | | | | | | | | * |
| | Exceptions | | | | | | | * | |
| SCHOOL INVESTMENT MODEL | | | | | | | | | |
| | Achievement Data | | | | | | | | * |